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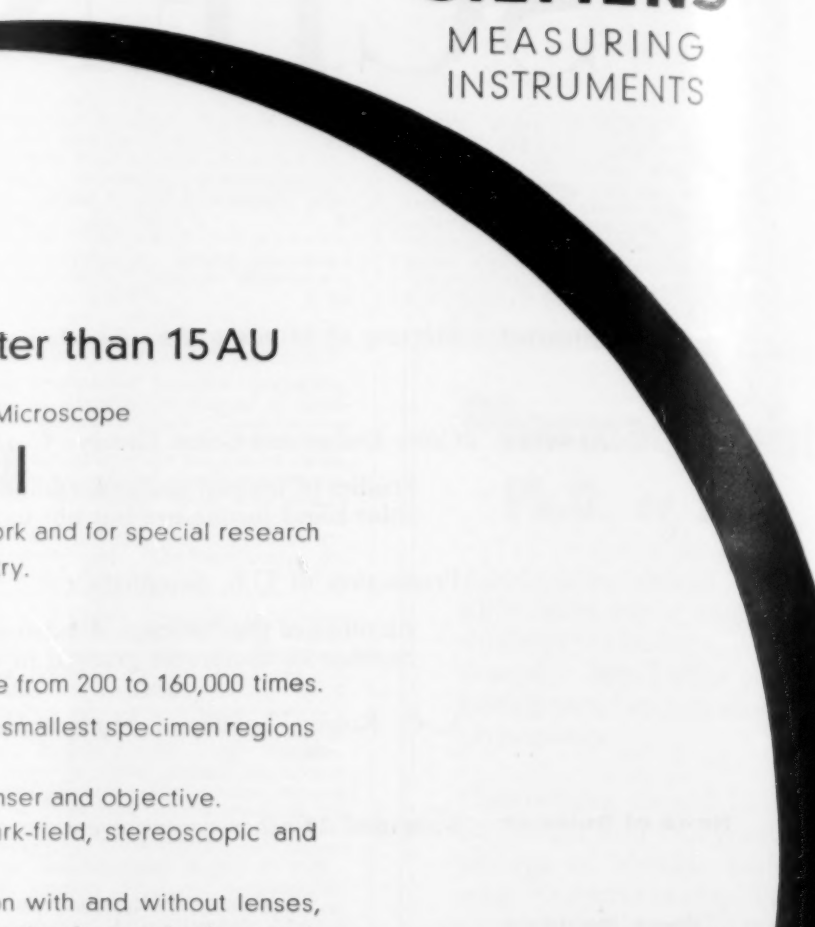

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Meeting of Minds

A convenient property of the five problems discussed by the recent AAAS-sponsored Parliament of Science is that they all admit of much the same answer. In each case something about science needs to be increased or improved or both—its support, its organization, its communication, its students, its teachers. But this is just to recognize the present need to help science help the nation. A balancing of other considerations comes into play in deciding upon the best means to achieve these ends. And so on 15, 16, and 17 March the parliament was held. And accordingly, it proved to be a lively, if sometimes frustrating, gathering.

The question of means most hotly debated was that of defining the proper place of the Federal Government in research and education. Some participants urged increased federal aid. Others argued that responsibilities in this area belong to the state and local governments and to private agencies. But whatever position members took on this and similar matters, all were at pains to distinguish between questions of policy and questions of fact and between their roles as citizens and their roles as scientists.

To arrive at a set of recommendations, the parliament, which numbered something like 100 members, split up into five working subgroups, one for each of the problems tackled. The subgroups then reported back to the collected assembly with sets of proposals, which were discussed and put to vote. Although the parliament constituted a distinguished and representative body of scientists and thinkers, it did not claim to speak for any group other than itself. In fact, it spoke only for its own majority, for the rules of the meeting did not insist upon unanimous agreement. Among the final recommendations was one opposing the creation in the Government of a separate Department of Science and another endorsing the coordinating function of the National Science Foundation. The official report of the parliament is now in preparation and will appear in a subsequent issue of *Science*.

As a first effort at this kind of operation, the parliament experienced several difficulties. One difficulty arose from the large size of the working groups and the shortness of time. The result was that, in the interests of agreement, important details of how much, of where, and of when had to be left unspecified. Another difficulty arose from the parliament's attempt to address a very broad audience. The result was that considerable effort was devoted to saying a lot of things that most of its members would ordinarily have taken for granted. The fear was that if the parliament came out in favor of A, without mentioning B, in which it was also in favor, then some people might interpret the omission of B as the rejection of B.

How effective was the parliament in helping science help the nation? Certainly, it gave the participants an opportunity to benefit from each other's knowledge and experience. And certainly, it served as a demonstration that the scientific community, and in particular the AAAS, is much concerned about the problems of fostering and utilizing science. But any full evaluation of the impact of the parliament will have to await future developments. We shall have to see whether any of its more specific recommendations find their way into public policy, and, if so, how they work out.—J. T.

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CURRENT PROBLEMS IN RESEARCH

Color Defect and Color Theory

Studies of normal and color-blind persons, including a subject color-blind in one eye but not in the other.

C. H. Graham and Yun Hsia

Different color theories differ greatly in matters of detail, but in one thing they are in agreement: the data of color vision cannot be accounted for in terms of the actions of a single set of receptors or processes with homogeneous characteristics. Rather the facts probably require the postulation of three or more sets of elementary mechanisms, the interactions of which provide the data of various discriminations of color. Thus, the Young-Helmholtz theory (*1, 2*) presumes the existence of three groups of receptors with different absorption characteristics, while the Hering theory (*3, 4*) postulates the existence of three pairs of antagonistic processes in the neural pathways of the visual system. Other theories make use of other devices to account for the phenomena of color.

Theoretical discussions of color vision have, since the time of Young, been influenced to a great extent by considerations of color blindness. It is interesting that Young, at the time he put forward his account of color in the Bakerian lecture for 1801, discussed the important theoretical role of color blindness despite the fact that reliable knowledge of that subject had been in existence for less than a quarter of a century (*5*). The reason for the theoretical importance of color blindness is not far to seek. In its simplest form, as exemplified in Young's ideas, one can think of a specific form of color deficiency as representing the loss of one of the fundamental processes from the total set that exists in normal vision. Since on this basis the eye of the color-blind can be thought of as essentially a reduced system, involving fewer than the normal number of fundamental processes, it might be expected that one could evaluate the missing process by comparing the color discriminations of a normal and color-blind eye. We shall see that such an expectation has, at best, some but certainly not complete support in what is known of the facts of color blindness.

Types of color blindness. There are several kinds of color-blind individuals classifiable in relation to normal subjects and to each other on the basis of their performances in different test situations.

Normal individuals are called *trichromats*. They can achieve a match between two mixtures of lights if one of the mixtures is a combination of a spectral color and a single color from a given unchanging set of three, called primaries, while the other mixture consists of the two remaining primaries. Conventionally, it is said that any spectral color can be matched by a mixture of three primaries, one of the primaries (the one mixed with the spectral color) having a negative value assigned to it. It is by reason of the match involving three primaries that persons with normal color vision are called trichromats.

Dichromats constitute a major class of color-blind individuals. Individuals of this group can establish a match between two mixtures that involve a spectral color and two primaries. Most dichromats are red-green blind; they "confuse" red, yellow, and green. The general class of dichromats may be subdivided into at least three types. The first class is the *protanope* whose sensitivity to wavelengths in the red end of the spectrum is greatly reduced. Another class is the *deuteranope* whose sensitivity is not deficient in the *red*. Protanopes and deuteranopes match a yellow to any amounts of red or green which will give an appropriate matching brightness (or luminance). A third type of dichromat, the *tritanope,* confuses blue and green (*6*).

Nothing will be said in what follows about *monochromats*, individuals who can match all wavelengths of the spectrum against any other wavelength or a white light by the proper adjustment of luminance, nor shall we elaborate on the functions of *anomalous trichromats*, people who, despite the fact that they confuse parts of the spectrum, still need three primaries to match a single wavelength.

The present experiments. This paper (*7*) is concerned with the visual functions of protanopes and deuteranopes, especially deuteranopes. It deals in particular with two theoretically important problems: (i) How is brightness sensitivity distributed in the spectrum for protanopes and deuteranopes? (ii) What colors do such persons *see*? On the basis of the experimental data, some proposals are made bearing on the nature of color function generally and dichromatism specifically (*8*).

Luminosity Curves of Dichromatic and Normal Subjects

The luminosity curve shows how the sensitivity of the eye varies for various wavelengths. Sensitivity (or luminosity) is measured in terms of the reciprocal of the energy required, for example, to pro-

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duce threshold. Figure 1 shows the luminosity curve for the normal subject as well as the curve for the protanope and deuteranope (*9*). Sensitivity for the foveal cones of the normal subject is low in the blue, at a maximum in the yellow-green, and low again in the red.

The curves, as drawn by Hecht and Hsia (*10*), show the data of Pitt (*11*) for dichromats and Gibson and Tyndall (*12*) for normal subjects. The figure shows that, compared with normal luminosity, the curve for the protanope seems to be displaced toward the blue, whereas the deuteranope's curve is displaced a little toward the red.

It has classically been considered that protanopes show a loss of sensitivity in the red part of the spectrum. It is not so certain, however, that deuteranopes show a decrease in sensitivity in any part of the spectrum.

The curves in Fig. 1 are drawn in the traditional way of considering each luminosity function by itself and by placing the point of maximum luminosity for each at 100 percent. It will be shown that this method of representing data provides a difficulty, for it does not tell us whether the sensitivities at the 100-percent values differ in absolute value. For example, one can ask: Does the 100-percent value for the protanope refer to the same energy value as the 100-percent value for the normal subject? Arguments based upon comparisons of curves that demonstrate arbitrarily set maxima are certainly not conclusive. Specifically, the question arises whether the curves of Fig. 1 really have the same height in energy ordinates, and if not, what their relative heights are. This is the question with which we are now concerned.

If color blindness is assumed to represent the loss or inactivation of one of three receptor systems, then the loss of a receptor system should show itself in some loss of brightness in the spectrum as seen by the color-blind. One might expect, for example, each curve for a color-blind subject (Fig. 1) to have a lower maximum than the curve for normal subjects. Abney (*13*) drew such lowered luminosity curves for color-blind subjects. However, his reduced curves were not found from measurements but were formulated in terms of theory. Such reduced curves have only been presented once as the result of experimental research: by Hecht and Hsia (*10*) eleven years ago.

Because of the need for more information on this general question, we decided to investigate the relative heights of the three curves shown in Fig. 1 by measuring the actual energy thresholds of color-blind and normal subjects in different parts of the spectrum. The idea is to determine for a given portion of the spectrum the light energy required at the foveal threshold of normal persons and of color-blind persons, and to do this for different parts of the spectrum.

Selection of subjects. The testing of our subjects involved the usual "screening" tests for color-blindness, the Ishihara and Stilling plates in particular, as well as the determination of the luminances of red and green required to match a yellow on the Hecht-Shlaer (*14, 15*) anomaloscope. In addition, determinations were made, in the case of the protanopes and deuteranopes, of the neutral point in the spectrum—that is, the narrow wavelength band that dichromats see as white. (Normal subjects never see spectral white.) The determinations of the neutral point were made with a modified Helmholtz color mixer (Hecht and Shlaer, *14*). Our final experimental groups included seven normal subjects, five protanopes, and six deuteranopes. The subjects numbered 16 men and 2 women between the ages of 20 and 35 years. (Both of the women had normal vision.)

Apparatus and procedure. Stimulating energies of light were obtained by means of a double monochromator calibrated for radiant flux. The wavelength, energy, duration, and retinal position of the stimulus could be controlled. Observations involved finding the energy threshold for the foveal cones for many narrow wavelength bands throughout the spectrum. Exposure time of each stimulus flash was 4 milliseconds.

At the beginning of each session, the subject became dark adapted for 10 minutes, a sufficient time for the cones to gain full sensitivity. Then the spectral lights were presented to him and he indicated whether or not he saw the light.

Results on normal subjects. Figure 2 gives the average log sensitivity curves for the seven normal subjects, the five protanopes, and the six deuteranopes.

The basic data of these curves are relative energies required for the cones to respond to the spectral lights at the absolute threshold; the logarithms of the reciprocals of these values (that is, log sensitivity values) are here plotted.

The peak of the average curve is arbitrarily set at zero (that is, maximum sensitivity is set at unity). It is to be noted that absolute energies may be calculated by observing that, at $\lambda = 578$ millimicrons (mμ), the average normal threshold is 3.5×10^{-8} erg. This figure amounts to about 10,000 quanta. It may be compared with a figure of about 100 quanta at the cornea obtained by Hecht, Shlaer, and Pirenne (*16*) for the much more sensitive peripheral retina with a small stimulus of $\lambda = 510$ mμ exposed for 1 millisecond.

It is not necessary here to labor the general fact of the "humps" in the blue and in the orange of the normal curve, near 450 and 610 mμ. Presumably they are associated with the positions of curves representing the fundamental processes.

Results on protanopes. The average luminosity curve for five protanopes is given in the same figure. It is to be observed that the average curve for protanopes indicates a greatly increased energy requirement in the red end of the spectrum. In the blue, the energy requirement for protanopes is similar to that for normals.

Results on deuteranopes. Most writers

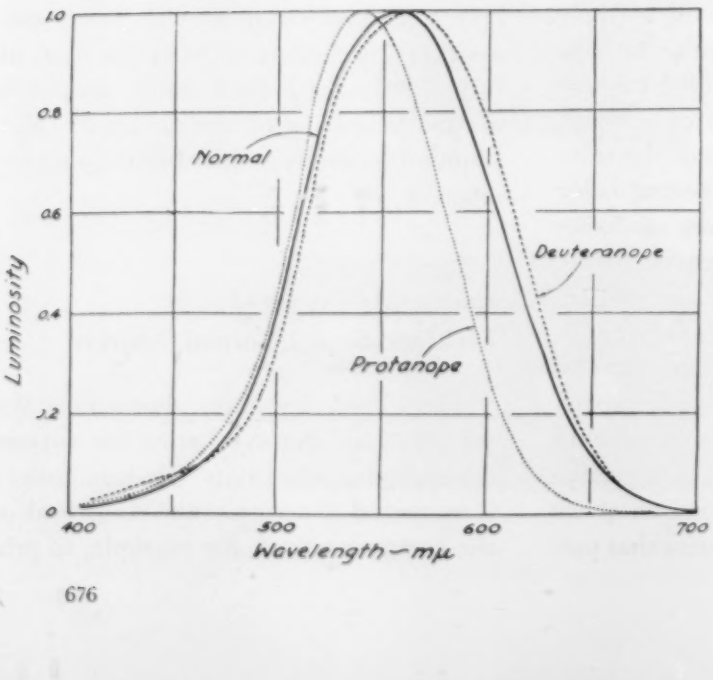
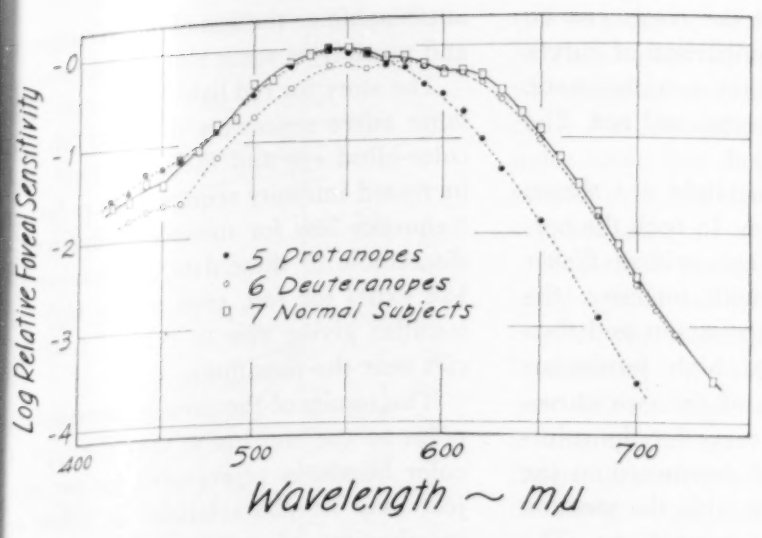


Fig. 1. Pitt's curves (*11*) for protanopes and deuteranopes and the data of Gibson and Tyndall (*12*) for normal subjects. The curves as drawn are from Hecht and Hsia (*10*.)



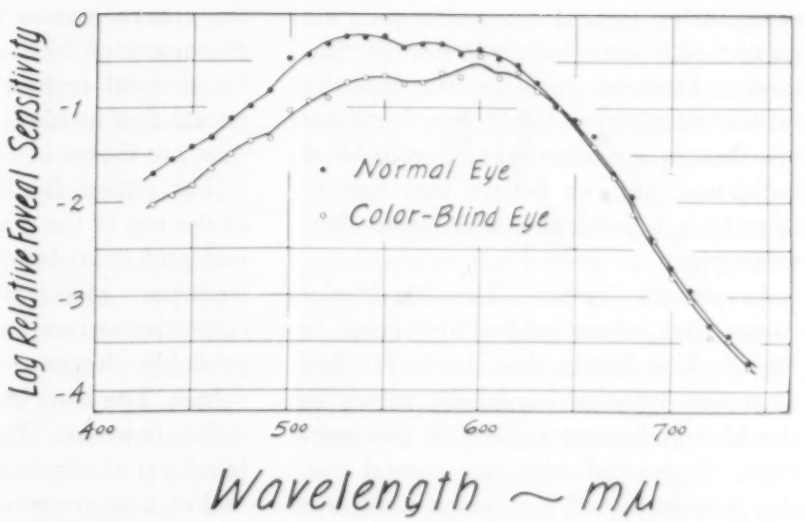


Fig. 2 (Left). The luminosity curves for normal subjects, protanopes, and deuteranopes in experiments by Hsia and Graham (*9*). Fig. 3 (Right). Luminosity curves of a unilaterally color-blind subject. The upper curve is the curve for the normal eye; the lower one, the curve for the color-blind eye. Data of Graham and Hsia (*24*).

on color blindness have not accepted the possibility that deuteranopes exhibit a loss of luminosity as contrasted with normals. Hecht and Hsia, on the basis of some determinations, maintained that a loss does occur, but their findings have met with considerable resistance, particularly by Walls and Mathews (*17*). Our experiment seems to demonstrate that deuteranopes usually do, in fact, lose luminosity. Five of our six cases demonstrate a loss.

The average log luminosity given by our deuteranopes is shown in Fig. 2. The luminosity for the deuteranope in the green and blue is less than the corresponding luminosity values for the normal. In the red, the values are comparable. According to our data, then, deuteranopes show a loss of luminosity in the green and blue.

General result. In general, one can say that the normal curve in this figure is a broad function that encompasses the extremes of the color-blind curves. The protanope has normal luminosity in the blue but shows loss in the red; the deuteranope shows normality in the red but a loss in the green.

Discussion. Interpretations of the data for color-blind individuals have been predominantly made in a context of trichromatic theory, developed from Young's notion that there are three receptor systems in the retina. These systems may be designated B, G, and R to indicate their properties of yielding blue, green, and red processes when they are brought into action by light. The discriminations produced by various parts of the spectrum result from the combined action of the three systems in different degrees. Thus the combined actions of the G and R system result in the seeing of yellow, while seeing white represents the combined actions of B, G and R. The action of the receptors contributes brightness as well as color, and luminance matches show the property of additivity.

Young supposed that the usual dichromatic forms of color blindness are due to the loss of one of the three receptor systems. Since Young's time this interpretation has usually been accepted in the case of protanopes: protanopes are presumed to have lost the R receptors.

Because the evidence did not seem to support an interpretation of loss for the deuteranope, another sort of account was required for this type of color defective. This account has entailed the idea of a "transformation" system, as described independently by Leber (*18*) and Fick (*19*). One might think of the transformation system as representing a failure of the R and G receptors to become differentiated from one another during development. In any case, the R and G receptors are presumed to be similar insofar as absorption goes, but they have different central connections. The result is that red stimulates both the central R and G systems. On this basis it would be expected that all long wavelengths would be called yellow by the deuteranopic subject. Leber and Fick's idea has seemed to be in line with data on subjects who were reported to be normal in one eye and deuteranopic in the other. Classically, such cases have reported that they see yellow in the long wavelengths.

Hecht and Hsia concluded on the basis of their experiment that Young's idea of a loss system was supported by their results. However, they were not clear about how the loss notion could account for the color-naming responses attributed to unilateral deuteranopes and protanopes. The reasons for the problem are clear. How could yellow, if it is a mixture of red and green, be reported in the absence of either red or green receptors?

Color Discriminations of a Unilaterally Color-Blind Subject

It is in connection with this question that we feel fortunate in having obtained the services of a young woman who gave color-blind discriminations with her left eye and normal discriminations with her right eye.

It would be difficult to exaggerate the importance of data obtained on unilaterally color-blind subjects. No ordinary color-blind subject can tell us how the colors he sees compare with those seen by a normal subject, but this is precisely what a unilaterally color-blind subject can do. He can make a direct comparison of colors seen by his color-blind and normal eyes.

Judd (*20*) reports that 37 cases of unilateral color blindness are described in the literature, only eight of which have provided data of value to a scientific analysis. The last of these studies was one by Sloan and Wollach (*21*) in 1948. [See also a recent historical note by Berger (*22*).]

Our subject's first test results seemed to indicate that she was deuteranopic, and so we began our experiments with the expectation that we should gain crucial information on the relation between deuteranopic luminosity loss and color naming. As our observations multiplied, we found that our subject did not give

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completely typical deuteranopic responses (*23*), particularly in hue discrimination. However, it seems clear that she is more nearly classifiable as a deuteranope than as any other type of color-blind individual, and we believe that her results have a particular bearing on deuteranopia.

Luminosity curves. The luminosity curves (*24*) of our subject are shown in Fig. 3. The luminosity curves for her two eyes differ in luminosity values in the blue and green regions of the spectrum. Contrasted with her normal eye, the luminosity of her color-blind eye shows considerable loss. In the red end of the spectrum both eyes have about the same sensitivity. It is possible that, as contrasted with the ordinary deuteranope, our subject's luminosity loss is greater and begins at wavelengths farther into the red than is usual. In any case, she shows a considerable loss in the green and blue for her color-blind eye as compared with her normal eye.

Flicker curves. We have believed it important to find out whether or not the types of luminosity loss that occur at threshold for our subject are maintained at high intensity levels. In order to investigate this problem we, together with Eda Berger (*25*), have measured flicker frequency thresholds at various luminances of different colors.

A considerable number of curves in the normal and color-blind eye were obtained with a number of color filters, but the general nature of the result can be demonstrated by a comparison of curves for spectral regions that a trichromatic person sees as blue, green, and red. The data are shown in Fig. 4.

The curves for blue light are shown at the top of the graph. In both the normal and color-blind eye, critical flicker frequency increases with intensity, the respective curves flattening out and then probably dropping at high luminance values. The positions of the two curves differ, however. The curve for the color-blind eye is displaced downward on the flicker axis compared with the position of the curve for the normal eye. The downward displacement is reminiscent of the effect of decreasing the area, hence the total number of excited receptors, of a flickering stimulus (Granit and Harper, *26*).

The curves in the lower left-hand graph represent the data for green light. The displacement of the curve for the color-blind eye below the position of the curve for the normal eye is striking. In magnitude it is considerably more than was shown for blue light. In general, the displacement means that, at any given intensity, fusion frequency is higher in the normal eye than in the color-blind eye in a manner comparable to an area effect. The latter statement may be especially significant, for it means that, if critical frequency represents activated receptor units, then the type of color blindness represented by our subject is attributable to the loss of green receptors and possibly of some blue receptors also.

The story for red light is different: the same curve represents the data for the color-blind eye and the normal eye. No increased intensity requirement or fusion frequency loss for the color-blind eye is discernible in these data. No luminosity loss exists for red, even at the high intensities giving rise to critical frequencies near the maximum.

The results of the present investigation point to the conclusion that the type of color blindness represented by our subject may be characterized as a loss or inactivation of some of the receptor mechanisms that mediate sensitivity in the green and blue portions of the spectrum. Furthermore, the data show that the selective luminosity loss for our subject is not a phenomenon that exists only at cone threshold levels.

Binocular color matching. Our experiments as discussed up to the present seem to indicate that the color-blind eye of our subject, like the eyes of deuteranopes generally, shows a maximum of luminosity loss in the green region of the spectrum. What data does our subject give us on binocular color matches involving her normal and dichromatic eye? What colors does she see in her color-blind eye?

The apparatus used in the experiment on binocular color matching was essentially a mirror stereoscope arranged so as to provide slits of color in the left and right eyes, a vertical slit in the left eye and a horizontal slit in the right eye. The subject regarded the essentially monochromatic color given by the vertical slit in her dichromatic eye and simultaneously observed, in the binocular field, the monochromatic color provided by the horizontal slit in her normal eye. The subject reported that, under her conditions of viewing, the horizontal and vertical slits seemed almost to touch at the middle of the latter but did not ordinarily overlap. Wavelengths stimulating the normal eye could be changed until a monochromatic band was obtained that, in the opinion of the subject, matched the color seen by the dichromatic eye.

The results of the experiment are summarized in Fig. 5. In general, it seems that, in her dichromatic eye, the subject matches all wavelengths greater than her neutral point (which occurs at about 502 mμ) against a wavelength in the normal eye lying at about 570 mμ. In a word, all wavelengths greater than 502 mμ in the dichromatic eye are seen as a yellow

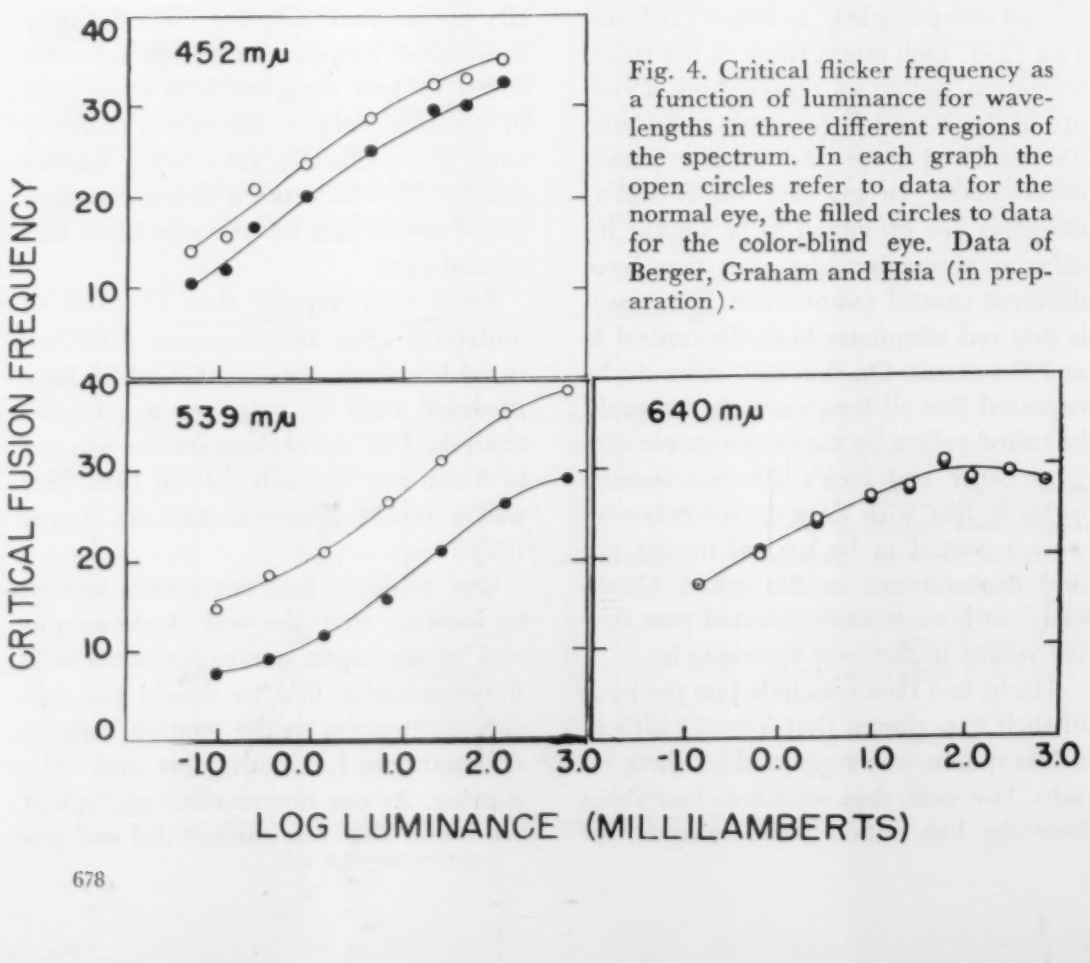

Fig. 4. Critical flicker frequency as a function of luminance for wavelengths in three different regions of the spectrum. In each graph the open circles refer to data for the normal eye, the filled circles to data for the color-blind eye. Data of Berger, Graham and Hsia (in preparation).

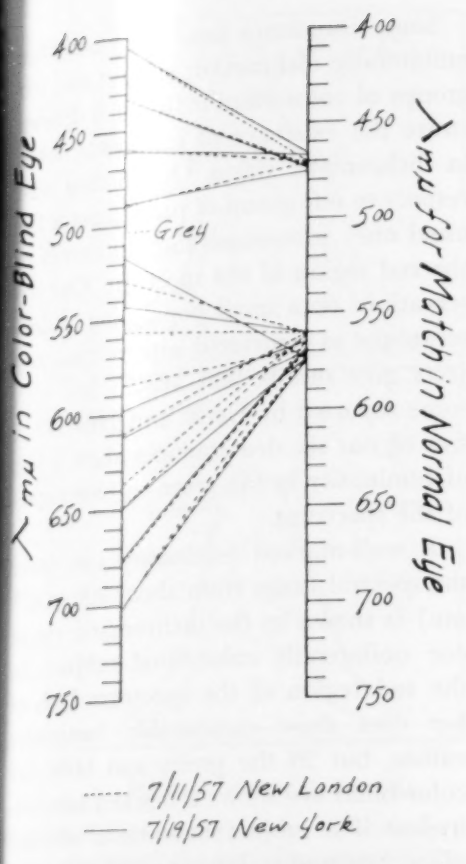

Fig. 5. Results of the experiment on binocular color matching. The wavelengths seen by the color-blind eye (left scale) are matched by the indicated wavelengths in the normal eye (right scale).

of about 570 mμ in the normal eye. Wavelengths shorter than the neutral point in the dichromatic eye are matched in the normal eye by a blue at about 470 mμ. Thus the two sides of the spectrum below and above the neutral point are seen, respectively, as a blue equivalent to about 470 mμ and a yellow equivalent to about 570 mμ in the trichromatic eye (*27*). These results are in accord with the data of several earlier experiments on unilaterally color-blind subjects as summarized by Judd (*20*).

Hue discrimination. Hue discrimination curves show how the just noticeable difference in wavelength, $\Delta\lambda$, varies with wavelength. Such data were obtained on our unilaterally color-blind subject by means of a modified Helmholtz color mixer (*14*). Careful attention was paid to making appropriate intensity adjustments so that all wavelength discriminations were obtained at the same constant level of luminance throughout the spectrum. A curve was obtained on each eye of our subject. The curves are presented in Fig. 6.

In general, the curve for the normal eye does not seem to be greatly different from the usual hue discrimination curve obtained on normal individuals (*28*). The poorest discrimination, as shown by the largest $\Delta\lambda$, takes place in the red. Minima occur in the middle range of wavelengths; and our subject shows especially low thresholds in this range. It is quite clear that the normal eye of our subject does not show defective hue discrimination.

The curve for the left eye, the color-blind eye, is an entirely different function. In the violet the curve shows some insensitivity to wavelength change, but near 450 mμ it shows a great rise in $\Delta\lambda$, indicating very poor hue discrimination. Discrimination improves to a minimum threshold value near 500 mμ, in the region of the neutral point; thereafter $\Delta\lambda$ rises to very high values near 600 mμ. The behavior of hue discrimination in the spectral region from 500 to 750 mμ is similar to that found in the usual deuteranope (*11, 28*).

Color mixture. The final set of results given by our subject are her data on color mixture (*29*). One way of specifying the data of color mixture is in terms of the trichromatic coefficients. Any color, including a spectral color, can be specified in terms of three numbers. Since the numbers add to unity, the position of a color on a two-dimensional grid, the chromaticity diagram, is uniquely specified when two of the coefficients are known. Each trichromatic coefficient represents the percentage contribution of one of three primaries in providing a match for a given color. A plot of the trichromatic coefficients against wavelength results in a graph of the sort shown in the upper graph of Fig. 7. In this graph the three ordinate values at each wavelength value represent the amounts of the three primaries as percentages of the unit color (more exactly, chromaticity) of the wavelength.

The curves of the upper figure are the data for our subject's normal eye (*30*). In these curves, a negative trichromatic coefficient means simply that a particular primary is combined with the test wavelength to match the two remaining primaries. The curves are to be contrasted with Wright's well-known results (*28, 31*), on ten normal eyes as represented by the dashed lines.

Our primaries are the same as Wright's: 460, 530, and 650 mμ. The units for the red and green primaries have been so specified that they are taken to be equal at 582.5 mμ, while the green and blue primaries are equal for the match at 494 mμ. Our color-blind subject's normal eye gives, except for minor differences, the same sort of color mixture data as are represented in Wright's data. In addition, it can be stated that the relative luminance values of the primaries for matches at 582.5 and 494 mμ are comparable to those reported by Wright.

The data for our subject's color-blind eye, shown at the bottom of Fig. 7, are entirely different from the data for the normal eye. The graph shows that our subject can match any wavelength of the spectrum with a combination of two primaries, 460 and 650 mμ (the units being taken as equal at 494 mμ). The dashed line represents Pitt's data (*11*) on the color mixture of deuteranopes.

The open and solid circles indicate two different types of result that were obtained in the short wavelength region depending on the method used. (i) If the subject matched a given short wavelength by a mixture of the two primaries, 460 and 650 mμ, then the results are as given by the solid-circle curves. They show that, as wavelength decreases below 460 mμ, more and more of the red primary must be added to the blue primary to make a match. In a word, the exhibited by Pitt's subjects. It should be noted that the small degree of negative red shown by the open circles. This result is much closer to Pitt's data than are our results, even though our subject did not mary to make a match. In a word, the primaries, the result is different, as is to match the mixture of red and blue test light is mixed with the red primary performed by Pitt's method, in which the approach 410 mμ. (ii) If mixtures were become less and less saturated as they colors at the blue end of the spectrum

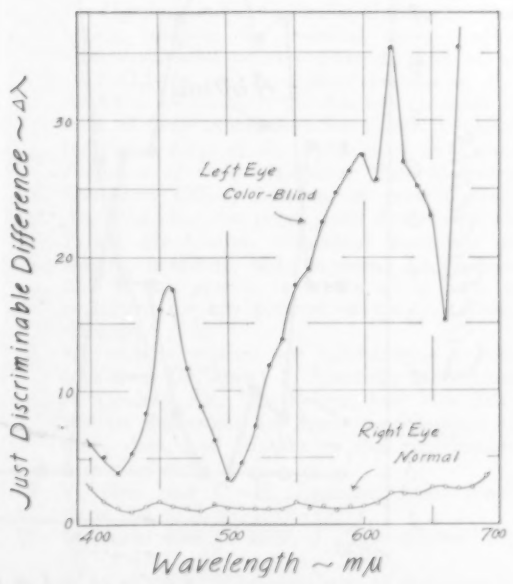

Fig. 6. The hue discrimination of a unilaterally color-blind subject. The open circles refer to data for the normal eye; the filled circles, to data for the color-blind eye.

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pointed out that our first method gives results that seem to be in line with our data on hue discrimination. (It will be remembered that our subject's dichromatic eye gave good hue discrimination thresholds in the short wavelength region of the spectrum.)

Discussion

Consider now the significance of some of our data.

First, the data on color mixture demonstrate that our unilaterally color-blind subject has normal vision in her trichromatic eye and dichromatic vision in her color-blind eye. This finding means that we possess a degree of specification that was often lacking in early experiments on unilateral color blindness. We are surer of the status of our subject than were most of our predecessors. The results given by our subject on hue discrimination show the usual low thresholds characteristic of the normal eye and the high thresholds of the dichromatic eye, except, for the latter, in the blue region below 450 mμ, where discrimination is better than the usual deuteranope's.

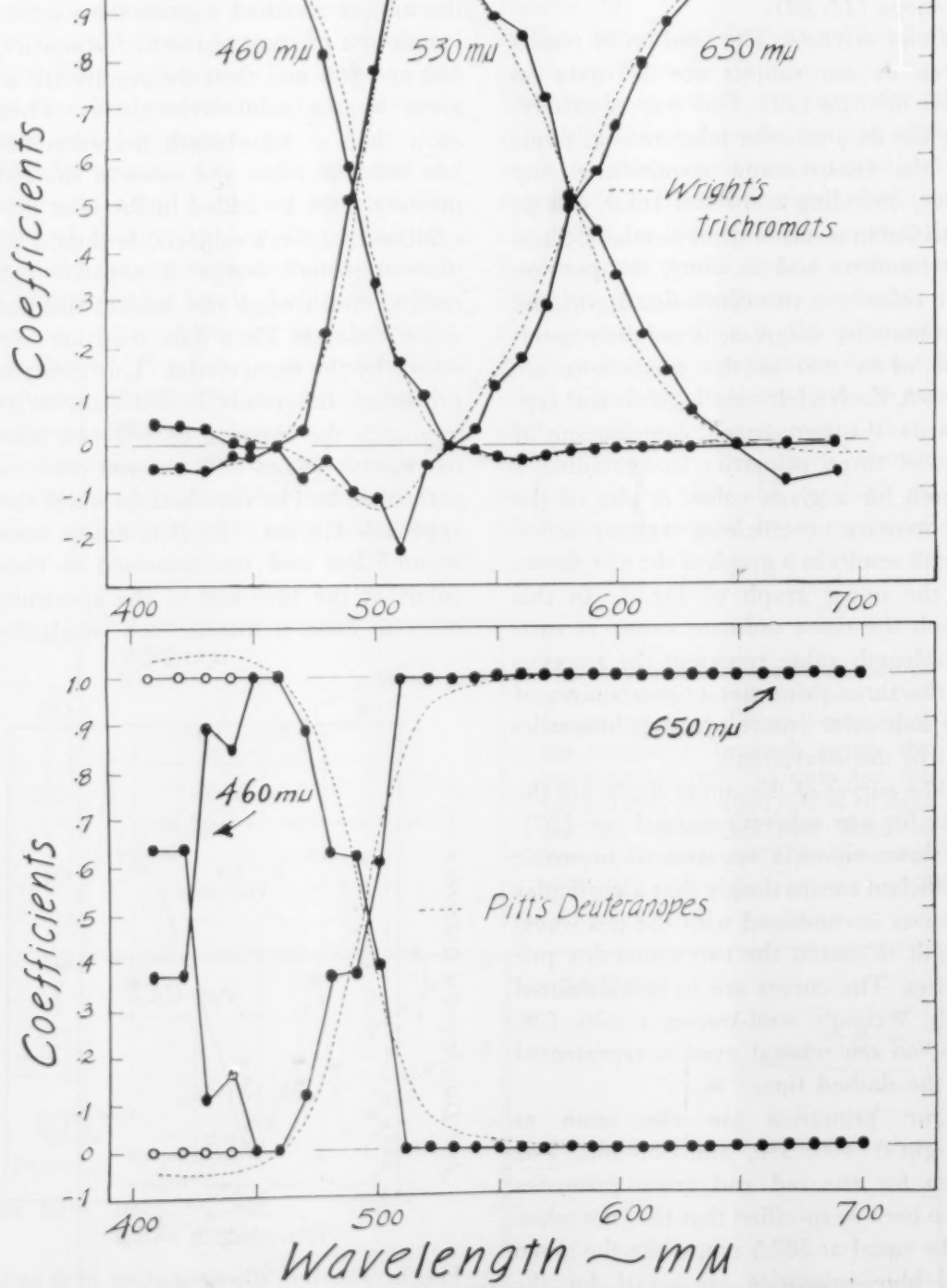

Fig. 7. The upper curve gives the trichromatic coefficients for the normal eye of our unilaterally color-blind subject. The dashed line represents Wright's data (*28, 31*). The lower curve gives the dichromatic coefficients for the color-blind eye of the same subject. The dashed lines represent Pitt's data (*11*) for deuteranopes.

Some important results on both our unilaterally dichromatic subject and our groups of color-blind individuals demonstrate the existence of luminosity losses in dichromatic vision. Our finding with respect to our group of protanopes is the usual one: protanopes lose luminosity in the red region of the spectrum. Our observations on a small population of deuteranopes as contrasted with normal subjects give results that are in line with some reported by Hecht and Hsia (*10*): five of our six deuteranopes show a loss of luminosity in the green-to-blue region of the spectrum.

A well-marked luminosity loss (over the spectral range from about 400 to 625 mμ) is shown by the dichromatic eye of our unilaterally color-blind subject. In the red region of the spectrum both of her eyes show comparable luminosity values, but in the green and blue, her color-blind eye shows a marked luminosity loss. The subject shows clear evidence of a luminosity loss over the spectral range from about 625 to about 450 mμ.

These results mean that luminosity loss is not only the usual finding for protanopes; it also exists in deuteranopes.

The second main result of our experiment concerns the findings on binocular color matches as given by our unilaterally color-blind subject. It has been demonstrated that her color-blind eye sees two hues: blue below the neutral point at about 502 mμ and yellow above it. As shown by binocular color matches, the blue she sees is equivalent, in her normal eye, to a wavelength of about 470 mμ; the yellow, to about 570 mμ.

How can these two sets of results, the one on luminosity loss and the one on binocular color matching, be reconciled within a coherent account?

What will now be presented is a statement that may have some of the advantages of the Fick-Leber hypothesis in accounting for the seeing of blue and yellow in the spectrum by protanopes and deuteranopes. It is hoped that the description can give a possible explanation of how luminosity losses can also occur in line with a transformation or "collapse" system, thereby removing what has been a shortcoming of such an account.

Let it be supposed that in deuteranopia, for example, the R fundamental curve in the upper graph of Fig. 8 (the presumed sensitivity curve for the R receptors) moves toward the short-wave part of the spectrum, with of course a change in sensitivity brought about by virtue of the transformed absorption ma-

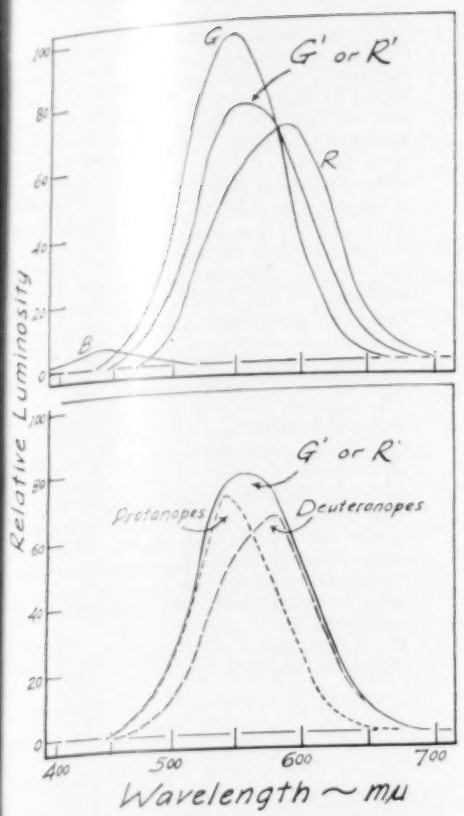

Fig. 8. Theoretical curves. The upper graph represents the transformation of the R and G curves (to superimposed R′ and G′ curves) to provide for the seeing of yellow by a dichromat who shows no luminosity loss. The lower graph represents the effect, for protanopes and deuteranopes, of luminosity losses.

terials. The new curve can be called R′. At the same time, the green fundamental curve G moves toward the red and becomes G′. (The blue fundamental curve will be disregarded in what follows.)

The curves, in their new positions, meet certain requirements. (i) Spectral brightnesses due to R′ and G′ must be in the same ratio at all wavelengths in order to give yellow. (The ratio shown in Fig. 8 is taken to be unity—that is, the R′ and G′ curves are superimposed.) A wavelength that stimulates the now identical R′ and G′ substances gives yellow, for although both fundamental processes have the same absorption spectrum, they are connected centrally with the usual R and G mechanisms. (ii) The spectral brightnesses of R′ and G′ add to give normal sensitivities. The dichromat represented by the latter requirements shows no luminosity loss. (We have already stated that one of our deuteranopes could be so described.)

Any sensitivity loss can now be introduced, as in the lower graph of Fig. 8, by assuming a curve for deuteranopes (or protanopes for that matter) that lies beneath the normal sensitivity curve as shown in the lower graph of the figure. The sensitivity losses in this figure were computed on the basis of the group data for protanopes and deuteranopes given in Fig. 2.

The lower curves of Fig. 8 do two of the things we want them to do: (i) They account for the seeing of yellow by dichromats in the long-wave region of the spectrum, in a manner not unlike simple Fick-Leber theory (*18, 19*). (ii) They provide for the existence of luminosity losses in the eyes of both deuteranopes and protanopes. The implications of the account should probably be tested in further observations. Its main merit now lies in the extent to which it approximates a useful statement of how trichromatic theory can account for luminosity losses and the manner of seeing spectral colors by deuteranopes and protanopes.

Summary

It is important to find answers to two questions concerning the visual discriminations of dichromatic persons, especially deuteranopes: (i) Do such persons show a loss of sensitivity to various wavelengths of the spectrum as compared with normal subjects? (ii) What colors do they see?

A number of experiments were performed on the first question.

First, luminosity curves were determined on three groups of subjects, consisting respectively of five protanopes, six deuteranopes, and seven normal individuals. As compared with normal subjects, protanopes show a loss of luminosity in the red, whereas deuteranopes show a loss in the blue-to-green region of the spectrum (See *10*).

Second, we examined the luminosity curves of a subject whose right eye is classifiable (on the basis of color-mixture determinations) as normal and whose left eye is classifiable as dichromatic. (The hue discrimination curve for her dichromatic eye seemed comparable to the curve of the usual deuteranope except in the violet, where it manifested relatively good discrimination.) The luminosity function for this subject's dichromatic eye, determined by data on threshold and flicker, exhibits the same type of luminosity loss in the blue and green regions of the spectrum as was shown by our group of six deuteranopes.

Only unilaterally dichromatic subjects can tell us how colors seen by a dichromatic eye appear to a normal eye. In the color-blind eye, our unilaterally dichromatic subject sees wavelengths below and above her neutral ("grey") point (which occurs at 502 mμ) as, respectively, a blue equivalent to about 470 mμ and a yellow equivalent to about 570 mμ in her normal eye.

The results on (i) luminosity loss and (ii) the seeing of wavelengths above 502 mμ as yellow are considered theoretically. The seeing of yellow by deuteranopes and protanopes may be accounted for by an idea based on Leber-Fick transmation theory. It is proposed that the characteristic sensitivities of the red and green receptors become similar while no change takes place in their central brain connections. Losses may be introduced into the transformed sensitivity curves to indicate appropriate degrees of luminosity deficit for deuteranopes and protanopes.

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6. It has been proposed that a very rare type, the tetartanope, should also be listed. The tetartanope, it is claimed, also confuses blue and green, but whereas other dichromats can match a single region of the spectrum by white, the tetartanope can so match two such regions.
7. This work was supported by a contract between the Office of Naval Research and Columbia University and by a grant-in-aid from the Higgins fund of Columbia University. This article contains the essential content of a vice-presidential address given by one of us (C.H.G.) to the Psychology Section of the AAAS in December 1956. Further accounts of some of these experiments have been prepared for *Proceedings of the Symposium on Visual Problems of Color* (London: Her Majesty's Stationery Office, London, in press); *Proc. Am. Phil. Soc.* (in press); and *Symposium on Visual Mechanisms* (National Institutes of Health, Bethesda, Md., in press). Reproduction of this article, in whole or in part, is permitted for any purpose of the U.S. Government.
8. We wish to express our indebtedness to our colleagues Dr. Harry S. Sperling, Mrs. Anne H. Coulson, Dr. Eda Berger, and Mrs. Shakuntala Balaraman for many contributions of time, data, and content to the experiments here discussed.
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23. It should also be mentioned that Dr. Gertrude Rand and Miss Catherine Rittler of the Laboratory of Ophthalmology, Columbia University College of Physicians and Surgeons, kindly examined our subject and concluded that, although her right eye was normal, her dichromatic eye did not fit a simple category of classical color defect. We are indebted to Dr. R. L. Pfeiffer, of the Ophthalmological Institute, Columbia University College of Physicians and Surgeons, for the ophthalmological examination of our subject. No organic disease was found.
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27. A separate experiment on color naming gives data in line with the results on binocular color matching. The subject reports only two colors in her color-blind eye: blue below her neutral point at about 502 mμ, and yellow above the neutral point.
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29. Some experiments on color mixture were performed at Columbia University, but the final data were obtained in collaboration with Dr. Harry G. Sperling and Mrs. Anne H. Coulson, on the Fry colorimeter at the Medical Research Laboratory of the Submarine Base, New London, Conn. A detailed account of these and other findings will be prepared as a joint report from Columbia and the Medical Research Laboratory, under Bur. Med. Project Number NM22 01 20, by C. H. Graham, H. G. Sperling, Y. Hsia, and Anne H. Coulson. We are indebted to our collaborators and to Commander Dean Farnsworth and Captain J. Vogel, officer-in-charge of the Medical Research Laboratory, for their cooperation in these experiments.
30. The relative values of the luminous units of the primaries are $l_{490} = 0.051$; $l_{530} = 1.000$, and $l_{650} = 0.814$. Matches were made by flicker photometry between the first two at 494 mμ, and for the second and third, at 582.5 mμ. The luminous units are within the range reported by Wright (*28*) for his normal subjects. The experiments were done with retinal illuminances of test wavelengths equal in all cases to 500 trolands as established by flicker photometry.
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Production of U.S. Scientists

Trends in the number of doctorates granted in the major fields of science and in the humanities.

Office of Scientific Personnel,
National Academy of Sciences–National Research Council

Recent events have focused attention on the subject of the production of scientists in the United States. Discussion relating to science production inevitably involves educational problems outside the field of science specifically and factors affecting education generally in the United States. The present article is intended to furnish up-to-date information with respect to the output of scientists by the United States universities during the past 20 years and to put this in the context of long-term trends in advanced education.

The main body of data for this article is the doctorate records file built up over the past decade by the Office of Scientific Personnel of the National Academy of Sciences–National Research Council. Through the cooperation of all the graduate schools in the United States which grant third-level degrees, and by means of funds furnished by the Office of Naval Research, the National Science Foundation, the Carnegie Corporation, and the Ford Foundation, a comprehensive and accurate roster has been produced of all persons who have earned the Ph.D. degree or its equivalent in all the science and nonscience disciplines in the United States universities since 1936. Data for the periods 1936–1945 and 1936–1950 have been published previously (*1*). The data are now available for the first 20 years of this survey: 1936 to 1955, inclusive. The data for 1956 and 1957 are being checked for completeness and accuracy and are not yet available for publication. In addition, the Office of Scientific Personnel has drawn upon data previously assembled by Douglas Scates from many sources, including chiefly the United States Office of Education. These data, covering the years 1885 to 1935, were published by the American Council on Education in 1951 (*2*).

In compiling data for the long time span indicated above, a number of difficulties necessarily arise concerning such problems as definition of a field or discipline, the development of new interdisciplinary fields into specialties which acquire significance in their own right, and the convergence of fields originally dissimilar. These problems, however, are of importance chiefly with respect to the finer subdivisions of any discipline and do not preclude a clear picture where only a gross breakdown of general fields is concerned. In the present article, emphasis is placed on gross trends in major fields, while certain problems with respect to the minor fields are noted in passing.

Trends

Figure 1 represents the over-all production of doctoral degrees in all fields, compiled for the 70-year span 1885–1955. Because the production of doctorates has roughly doubled in each decade since the earliest records were maintained, it is convenient to show this gross trend on a semilogarithmic scale. The result is an approximation to a straight-line graph because of the logarithmic increment on the vertical axis. In Fig. 1, a straight line has been projected through

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the annual production data at a slope equal to a 7 percent per annum increment. The base period through which this line is drawn is the period 1936 through 1941, inclusive (the first six years covered by the doctorate survey of the Office of Scientific Personnel). An increment of 7 percent per annum, compounded annually, is closely equivalent to the "doubling every decade" approximation noted by a number of writers in earlier publications.

It can be seen from Fig. 1 that this 7 percent trend line yields a fairly close approximation for the whole 70 years of data accumulation, in spite of variations in definitions and methods of data collection. The two points in the curve at which production falls precipitously below the trend line are the periods of World War I and World War II. In each case, there is a postwar recovery which brings the production curve back to the long-term trend line.

In Fig. 1 the production of science doctorates has been plotted at twice the actual value in order to represent the data as superimposed on total production. This simple doubling formula could be used because, during the base period 1936–1941, the science and nonscience fields were equal. As any line separating these two general fields is necessarily somewhat arbitrary, it is important that the definition used here should be clearly understood. On the one side are those fields which are almost universally accepted as the natural sciences, including physics, chemistry, geology, biology, and the medical sciences (only third-level degrees are considered; not included are the M.D., D.D.S., and D.V.M. degrees). Also included here are mathematics and engineering. The remainder of the disciplines form the more heterogeneous group, including the social sciences, the arts, and the humanities. Somewhat arbitrarily perhaps, psychology, anthropology, and geography have been included in the latter group. An earlier attempt to split these fields into their natural science and social science components was found unsatisfactory because of varying opinions as to what constitutes natural and social sciences and the lack of information with respect to fields of specialization of the individuals in the several groups.

Figure 2 presents the data from the Office of Scientific Personnel doctorate survey for the years 1936–1955 for these two general fields, in linear rather than logarithmic form to facilitate direct reading. It can be seen here that the 7 percent per annum trend line, based on the first six years, simultaneously graduates both production curves. The significant fact for present consideration is that the curve for natural sciences has reached a plateau while that for other fields is still rising. Also, the natural sciences

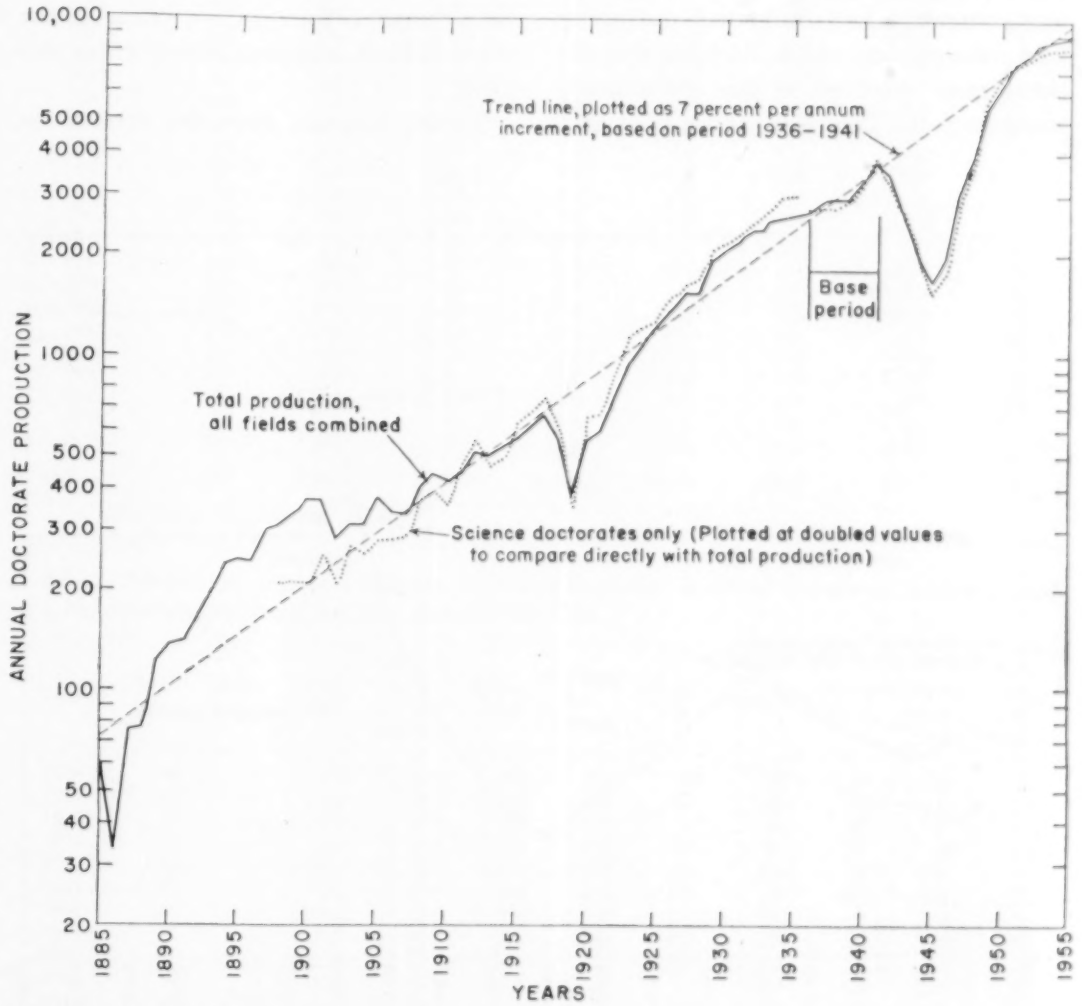

Fig. 1. Production of doctorates in United States universities, 1885–1955, plotted on logarithmic scale for straight-line projection.

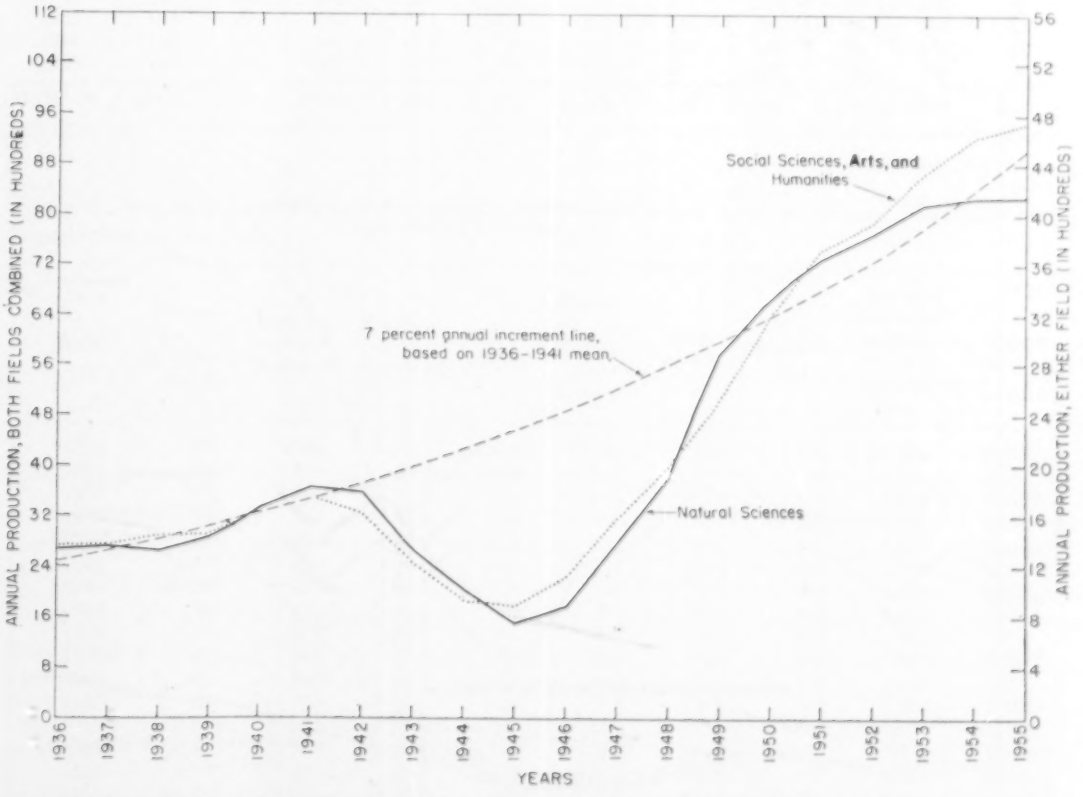

Fig. 2. Production of doctorates in United States universities, 1936–1955: science and nonscience fields. Natural sciences include both physical and biological sciences; social sciences, arts, and humanities are combined and include geography, psychology, and anthropology. The scale at left is for total production, all fields combined. The scale at right is for either field taken separately.

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have dropped below the long-term trend line, while the social sciences, arts, and humanities group is above the line. In general it can be seen that the response of the latter group to the war emergency was somewhat less sharp and the post-war recovery less rapid. At least one of the factors involved in this differential response is the fact that members of the latter group are older and that, for this group, there is typically a much longer time span between the granting of the bachelor and doctoral degrees. The typical B.A.–Ph.D. time interval for the natural sciences is four or five years; in the other fields it is approximately twice this time.

Figure 3 breaks down the data of the natural science field into physical science and biological science components and presents each production curve with its corresponding 7 percent per annum projection based on the first six years. Again the definition of the disciplines included within each major grouping is important in interpretation. The physical science group includes mathematics, physics, astronomy, chemistry, geology, and engineering. The biological sciences include biochemistry and the medical sciences but do not include any portion of the fields of psychology and anthropology.

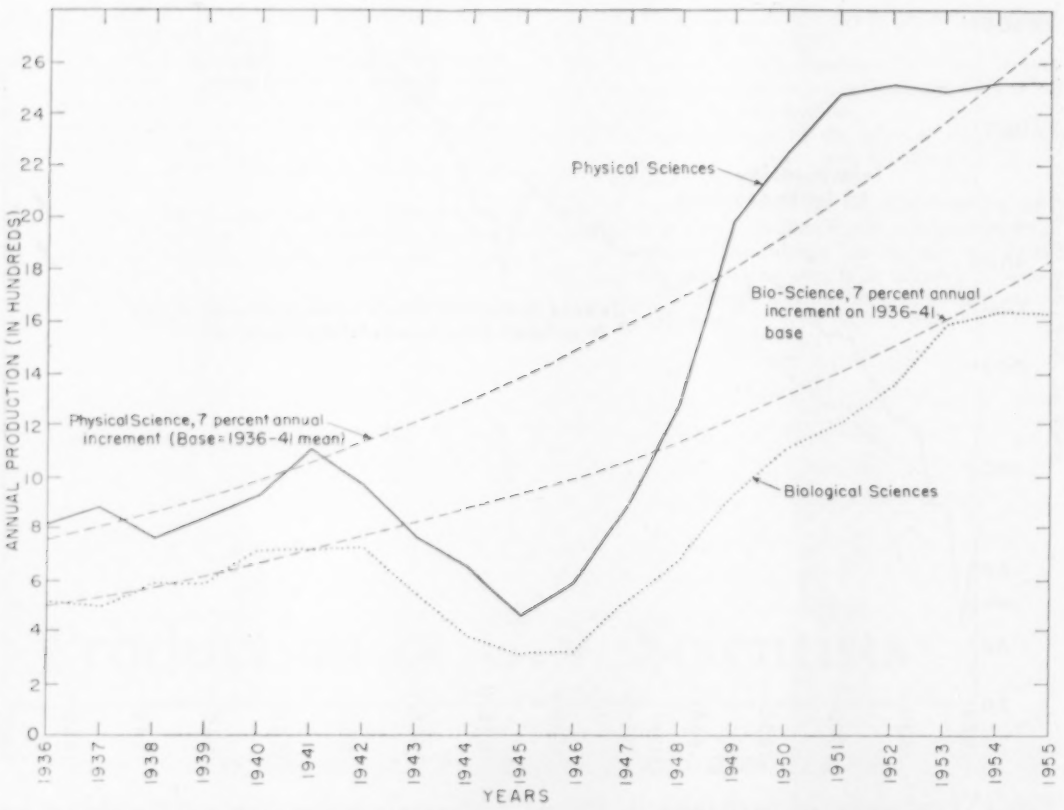
ANNUAL PRODUCTION (IN HUNDREDS)
YEARS
Physical Sciences
Bio-Science, 7 percent annual increment on 1936–41 base
Physical Science, 7 percent annual increment (Base=1936–41 mean)
Biological Sciences

Fig. 3. Production of doctorates in United States universities, 1936–1955: biological and physical sciences. Physical sciences include geology and engineering; biological sciences include biochemistry and medical sciences but not anthropology or psychology.

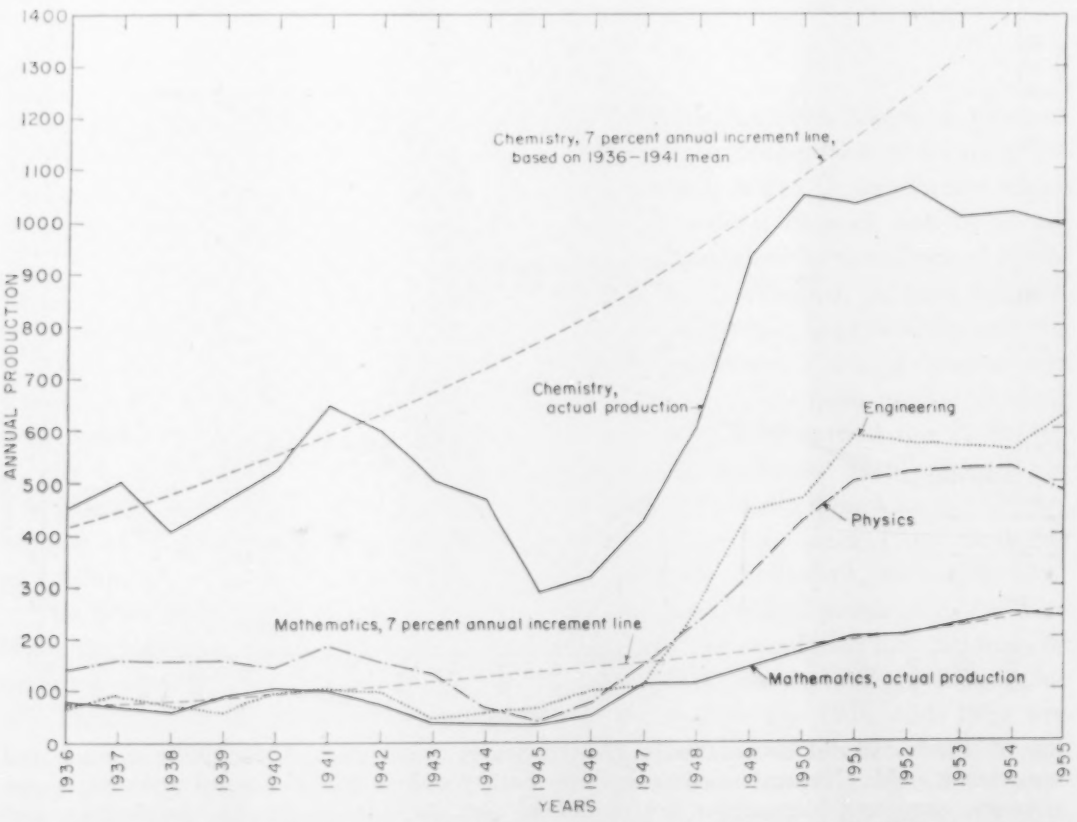

Fig. 4. Production of doctorates in United States universities, 1936–1955: physical sciences.

A phenomenon somewhat similar to the general difference between the science and nonscience fields mentioned earlier is apparent in the two graphs of Fig. 3. That is, the physical science group responds somewhat more sharply and quickly to the war period and to post-war recovery. Of particular importance at the present time is the fact that this group as a whole reached a plateau in 1951 and has continued on what is practically a dead level ever since. The biological science group, recovering somewhat more slowly, never quite reached its long-term trend line but struck a plateau two years later than the physical science group. This may be due to the fact that the bio-science group is, in general, composed of a somewhat older group of people and that there is a greater time lag between the granting of the bachelor's and doctor's degrees than is true for the physical science group.

Figure 4 gives a further breakdown of the physical science field. Omitted from this graph, in order to avoid overcrowding, is the curve for geology, which in general runs somewhat below that for mathematics. While geology includes some specialists who are more closely related to the bio-sciences than to the physical sciences, a preponderance of the members of this group are felt to belong properly in the physical science group. Biophysics, a very small group, is included in this tabulation with the biologists rather than the physicists.

The most striking feature of Fig. 4 is the fact that the largest field, chemistry, has never returned to its 7 percent trend line and has actually been on the decline most of the time since 1950. The second striking feature of this graph is that engineering has come up from being the smallest field in 1936 to being the second largest since 1948. Rather interesting is the fact that the upward trend in engineering as a Ph.D. field began during World War II and continued uninterruptedly until 1951. The relation of chemistry to engineering is of some im-

portance he... Although the depression in the chem... figures can be attributed in part to a... ift of some people from chemistry t... emical engineering (one of the large... components of the engineering gro... the downward trend in chemistry o... the past six years cannot be attribute... to this source, as engineering itself ha... been on a plateau since 1951. Altho... the graduating 7 percent curves are omitted for physics and engineering, to avoid cluttering the chart, some interesting facts about them should be noted. In engineering, during the first six years, the production rate is almost exactly equal to that in mathematics. The mathematics trend line will therefore suffice as a close approximation to that for engineering. It is readily seen, therefore, that engineering has for several years produced twice as many doctorates as the 7 percent per annum increment would have led one to predict on the basis of the 1936–1941 figures. In physics, the trend line, if introduced, would have shown that the actual production exceeded expectations from 1950 on, but that the recent decline has brought the actual and projected figures almost exactly together.

Figures

Table 1 includes the actual figures for the fields included in the natural science group. Table 2 depicts the major fields within the social sciences, arts, and humanities groupings. Because of the large number of fields, only those with a production figure of over 700 within the 20 years covered by this study have been included in this table. Fields not tabulated include the following (20-year production totals are in parentheses): anthropology (484), geography (469), law and jurisprudence (344), international relations (291), linguistics (104), home economics (93), library and archival science (71), statistics (6...), writing and journalism (38), and miscellaneous other fields not readily categorized (137).

Table 3 gives summary figures for the physical science and bio-science subgroups and for the natural science group as a whole. It also includes the summary figures for the fields of the social sciences, arts, and humanities group, with breakouts of certain significant components of this group. Psychology has been included as a separate group because of the fact that it has had a phenomenal growth during the past 20 years, its expansion bearing certain resemblances to that of engineering, but undoubtedly having

Table 1. Number of doctor's degrees awarded in major fields of the natural science group during the period 1936–55.

Year	Mathematics	Physics, astronomy	Chemistry	Engineering	Geology	Biochemistry	Biology	Medical science
1936	78	141	451	67	72	8	479	22
1937	73	160	501	90	54	21	466	9
1938	61	154	405	65	69	108	446	25
1939	90	156	467	59	59	116	456	16
1940	102	144	525	95	63	128	551	28
1941	97	185	649	106	67	104	580	29
1942	75	154	597	76	66	136	559	28
1943	41	130	502	47	41	114	423	15
1944	40	63	469	60	18	97	251	28
1945	38	43	290	65	24	72	220	17
1946	53	71	319	100	37	30	266	19
1947	116	148	424	115	61	42	458	18
1948	117	224	604	251	67	90	563	20
1949	143	319	932	445	121	123	773	33
1950	174	421	1,050	469	129	127	926	48
1951	204	499	1,033	585	148	140	1,004	49
1952	204	519	1,061	569	149	151	1,134	59
1953	226	523	1,006	563	167	179	1,353	45
1954	247	527	1,017	560	161	200	1,352	85
1955	240	481	993	624	175	210	1,311	105
1936–55	2,419	5,062	13,295	5,011	1,748	2,196	13,571	698

Table 2. Number of doctor's degrees awarded in major fields of the social sciences, arts, and humanities group during the period 1936–55.

Year	Sociology	Economics	History	Political sci.; public admin.	Education	Foreign languages	English	Speech	Philosophy	Religion, theol.	Business, commerce
1936	34	98	130	47	333	177	142	12	55	80	18
1937	53	107	144	56	349	169	160	21	42	77	13
1938	48	124	159	50	360	170	159	20	43	81	13
1939	57	106	164	49	361	158	159	15	55	88	24
1940	50	117	164	68	456	179	172	24	51	81	17
1941	74	151	185	63	468	181	191	39	53	101	21
1942	62	134	168	60	479	150	177	33	46	138	23
1943	44	80	120	41	385	114	120	20	30	102	17
1944	33	59	58	33	305	70	68	13	36	105	17
1945	30	54	68	20	284	71	73	19	26	132	12
1946	45	80	117	35	337	71	113	22	26	88	14
1947	76	135	168	55	445	120	164	37	40	136	18
1948	70	142	145	88	665	135	164	65	51	155	25
1949	98	185	224	108	817	158	177	45	61	185	39
1950	131	248	270	136	1,009	213	236	72	92	182	55
1951	142	295	341	139	1,116	202	297	94	87	184	64
1952	147	303	296	133	1,319	178	263	106	89	176	83
1953	183	293	350	150	1,426	202	332	123	110	161	85
1954	198	341	366	150	1,518	215	344	138	86	178	89
1955	188	359	333	182	1,584	216	327	130	99	186	96
1936–55	1,763	3,411	3,970	1,663	14,016	3,149	3,838	1,048	1,178	2,616	743

Table 3. Summary figures for the science and nonscience subgroups and the doctorate population as a whole.

Year	Physical sci., engineering, geology	Biology, medicine, biochem.	Natural sci., medicine	Psychology	Social sci., (including psychology)	Education	Arts, humanities	Social sci., arts, humanities, psychology, educ.	All fields
1936	809	509	1,318	110	458	333	531	1,322	2,640
1937	878	496	1,374	113	507	349	524	1,380	2,754
1938	754	579	1,333	119	525	360	529	1,414	2,747
1939	831	588	1,419	116	530	361	546	1,437	2,856
1940	929	707	1,636	125	576	456	575	1,607	3,243
1941	1,104	713	1,817	112	631	468	639	1,738	3,555
1942	968	723	1,691	125	588	479	640	1,707	3,398
1943	761	552	1,313	86	399	385	444	1,228	2,541
1944	650	376	1,026	67	277	305	343	925	1,951
1945	460	309	769	58	243	284	368	895	1,664
1946	580	315	895	82	398	337	370	1,105	2,000
1947	864	518	1,382	118	594	445	560	1,599	2,981
1948	1,263	673	1,936	169	650	665	679	1,994	3,930
1949	1,960	929	2,889	269	943	817	771	2,531	5,420
1950	2,243	1,101	3,344	342	1,210	1,009	792	3,011	6,355
1951	2,469	1,193	3,662	483	1,500	1,116	1,090	3,706	7,368
1952	2,502	1,344	3,846	580	1,541	1,319	1,063	3,923	7,769
1953	2,485	1,577	4,062	653	1,733	1,426	1,198	4,357	8,419
1954	2,512	1,637	4,149	665	1,831	1,518	1,277	4,626	8,775
1955	2,513	1,626	4,139	728	1,904	1,584	1,249	4,737	8,876
1936–55	27,535	16,465	44,000	5,120	17,038	14,016	14,188	45,242	89,242

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quite different causes. The field of education has been included as a separate field because of its overwhelming magnitude, representing as it does almost one-third of the total social sciences, arts, and humanities composite. The field of social sciences has been here defined to include geography, archeology, anthropology, sociology, economics, statistics (other than mathematical statistics), history, political science, and public administration. In the arts and humanities subgroup have been included business and commerce, international relations, area studies (only one case in 20 years), linguistics, all languages and literature (both English and foreign), speech, writing and journalism, library science, law, home economics, arts, music, architecture, philosophy, religion, and theology. The segregation of any particular field into one or the other of these two general categories—social sciences or humanities—may be rather arbitrary. It does not appear, however, that the shift of any field about which there is disagreement from one to the other of these two categories would profoundly alter the general trend of the data.

New Procedure

The figures and tables here given raise many questions regarding reasons for various trends and changes in trends and regarding educational policies and actions at local, state, and national levels that might bear on these production figures. For answers to most of these questions, more data are required. For example, information on trends in the demand for Ph.D. degrees and on kinds and levels of support available for students in the various fields is needed. More information with respect to the individuals included in the doctorate records is also needed. To meet this latter need, a change was made at the beginning of 1957 in order to secure much more information regarding the educational experience, age, marital status and dependents, and future employment and educational plans of each new recipient of the doctoral degree. With the accumulation of these data, it should be possible to answer many questions raised by the present study. The new data-collection procedure instituted in 1957 should also make it possible to process the data more rapidly and to bring production curves up to date more quickly in the future. Additional papers dealing with significant aspects of doctorate production and related questions will be published from time to time as appropriate. A fourth volume of the "Baccalaureate Origins" series (see *1*) is scheduled to appear in the late spring or early summer of 1958. When it is available, it will extend the data here presented through the calendar year 1956.

References and Notes

1. *The Baccalaureate Origins of Science Doctorates Awarded in the United States 1936–1950* (Office of Scientific Personnel, National Research Council, Washington, D.C., June 1948); *Baccalaureate Origins of Science Doctorates Awarded in the United States 1936–1950*, Office of Scientific Personnel, National Academy of Sciences–National Research Council, Publ. No. 382 (Washington, D.C., 1955); *Baccalaureate Origins of Doctorates in the Arts, Humanities, and Social Sciences Awarded in the United States 1936–1950*, Office of Scientific Personnel, National Academy of Sciences–National Research Council Publ. No. 460 (Washington, D.C., 1956).
2. D. E. Scates, B. C. Murdoch, A. V. Yeomans, *The Production of Doctorates in the Sciences: 1936–1948*. A report of a project sponsored by the Manpower Branch, Human Resources Division, Office of Naval Research (American Council on Education, Washington, D.C., 1951).

C.-G. Rossby, Leader of Modern Meteorology

The sudden death of Carl-Gustav Arvid Rossby at his office in Stockholm, Sweden, on 19 August 1957, at the age of only 59, ended the career of a man who had shaped the development of modern meteorology in America as it rarely has fallen to the lot of one man to do in any scientific field.

Carl Rossby arrived in this country on a Scandinavian-American fellowship in early 1926, a young man of 27, bursting with that keen enthusiasm for his chosen work which has proved so stimulating to great numbers of students and professional colleagues and to many others who have been associated with him. Besides his training in theory at the University of Stockholm and three years of practical experience in forecasting in the Swedish Weather Bureau, Rossby had behind him the benefit of a year's sojourn at the Geophysical Institute in Bergen, during the early period of the creative development of the polar front theory by the Norwegian meteorologists under the inspiration of V. Bjerknes. In addition, he had made an extended visit at the Geophysical Institute in Leipzig.

At the time of Rossby's entry on the American meteorological scene, the science in this country was coasting along on the long-spent momentum gained from such American pioneers in the field as Ferrel, Abbe, and Bigelow. Professional activity in the science was limited to the Weather Bureau (primarily agricultural), the Navy, the Signal Corps of the Army, and the geography departments of a few universities. Professional training in modern meteorology did not exist; a career in the field could be entered upon only through one of the afore-mentioned Government services or as an adjunct to the study of geography and climatology in a few universities. Meanwhile, the first strong stirring of civilian and military aviation was beginning to call for a new deal in American meteorology and weather forecasting. Conditions were ripe for the incendiary spark which was Carl Rossby.

My friendship with Carl began in the Weather Bureau in Washington during 1926, where he was enthusiastically promoting the discussion and synoptic application of the new polar front theory of weather map analysis (which, up to that time, had been practically unheard of in this country), and attempting model tank experiments to prove the practical validity of the theory. His genius for stimulating creative scientific activity was quickly recognized, and he was selected, in 1927, by the Daniel

Guggenheim Foundation for the Promotion of Aeronautics, to be the chairman of its new Committee on Aeronautical Meteorology. In this capacity he organized for Western Air Express of California, during 1927 and 1928, the first airways service in North America, modeled after the airways services on the European airlines in those countries where the development of commercial aviation at that time was far ahead of commercial aviation in this country. In 1928 Rossby was appointed associate professor of meteorology at Massachusetts Institute of Technology, to organize, in the department of aeronautical engineering, with Guggenheim support, the first professional course in modern meteorology in America. I joined him there in February 1929.

In the course of the next 10 years, under Rossby's inspiring leadership, first the course in meteorology and then the department of meteorology at M.I.T. rapidly assumed a leading role in the development of American meteorology —a role whose influence was felt also in the field of oceanography through Rossby's close cooperation with the Woods Hole Oceanographic Institution. During this period Rossby's particular interests ranged from problems of applied thermodynamics and eddy viscosity to the vertical and horizontal structure of wind and water currents and the mechanics of the large-scale flow patterns of the atmosphere and oceans. Most notable, perhaps, was his theory for the movement of the long circumpolar waves in the middle troposphere, depending on the latitudinal variation of the Coriolis parameter.

The two outstanding traits which were probably primarily responsible for Rossby's broad impact on the science of meteorology, during his years at M.I.T. and subsequently, were, first, his exceptional ability to think clearly both in terms of abstract theory and of practical application—that is, to combine dynamic theory and synoptic practice—and, second, his remarkable success in always attracting to himself and in stimulating to creative activity a group of able students and colleagues. It was the students he trained at M.I.T., and subsequently at Chicago, that left the permanent imprint of Rossby's genius on American meteorology.

After 10 years at M.I.T., Carl Rossby found the department of meteorology to be running so smoothly that he felt the need of a change of scene, with new problems to challenge his restless energies. The opportunity for such a change was offered in 1939 by an appointment to the U.S. Weather Bureau as assistant chief for research and education, which he accepted. However, he found that the academic milieu was better suited to his particular genius for self expression, so in 1941 he accepted a professorship at the University of Chicago and later, a distinguished service professorship, which he held until 1951. At Chicago, Rossby repeated his earlier achievement at M.I.T. by building around himself an outstanding scientific department in which theoretical and applied research were most successfully merged, and which continued the Rossby tradition of turning out exceptional leaders in the field of meteorology—no longer, however, without competition from other American universities. His group at Chicago took on an increasingly international flavor. Likewise his research associateship at the Woods Hole Oceanographic Institute, which had first been established in 1932, continued to be fruitful throughout his years at Chicago and right up to the time of his death.

During World War II, as expert consultant in the Office of the Secretary of War, and consultant on weather problems, Office of the Commanding General of the U.S. Army Air Force, Rossby took a leading advisory part in the crash program for training weather forecasters and for developing and applying the latest principles of forecasting to meet the needs of the armed services.

It was during his earlier years at Chicago that Rossby first applied the theoretical concepts which today are perhaps considered to constitute his most important contribution to meteorology. This consists, essentially, of the application of the barotropic vorticity principle to the determination of the large-scale horizontal motions of the atmosphere, to explain hydrodynamically the changing pattern of the general circulation in its larger features. The success of this approach to the forecasting, by numerical computation, of the upper-level flow patterns of the atmosphere is perhaps amazing in view of its strictly two-dimensional character. It is the basis of nearly all practical application of numerical weather prediction today. Pioneer work in this field was performed by Von Neumann's group at the Institute for Advanced Study in Princeton, in close cooperation with Rossby.

Although Rossby's professorship at Chicago was not terminated until 1951, the increasingly international scope of his work and interests brought him back to a professorship at the university of his native Stockholm in 1947. For some years his leadership or stimulating influence was exercised almost on a commuting basis between Stockholm, Chicago, Princeton, and Woods Hole. His last years were devoted increasingly to his International Meteorological Institute in Stockholm, established with the support of the United Nations Educational, Scientific, and Cultural Organization, where he succeeded once more in attracting to himself and leading an international group of young and active scientists. During these last years Rossby's interest in many world problems in meteorology continued strong and active; to the list of these was added at this time atmospheric chemistry.

Carl Rossby's sudden death removes from the world scene probably the strongest and most inspiring leader in the field of meteorology today. His greatness lies, not primarily in his written contributions, but in his amazing success in generating fruitful ideas and in developing and inspiring enthusiasm and creative effort among the many students and younger colleagues who have felt his influence. The place which he has left vacant will not be quickly filled.

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News of Science

Vanguard I

Vanguard I, the second U.S. satellite, was launched at Cape Canaveral, Fla., on 17 March by the Naval Research Laboratory's Project Vanguard, the Government agency assigned in July 1955 to the U.S. satellite program for the International Geophysical Year. The 3½ pound sphere, which is 6 inches in diameter, is traveling at approximately 18,000 miles an hour in an elliptical orbit that has an apogee of 2513 miles above the earth and a perigee of 407 miles. The figures exceed those for the three previous earth satellites (the two Soviet sputniks and the Army's Explorer I) chiefly because of the small size of the vehicle, which is purely a test sphere and which contains a minimum of instrumentation—two radio transmitters. Vanguard I is not officially an IGY scientific satellite, although Joseph Kaplan, chairman of the U.S. National Committee for the IGY, announced that its launching had been reported to IGY headquarters in Brussels.

Rocket assembly. The purpose of the firing was to test the 72-foot, three-stage Vanguard rocket, which represents a significant technical advance in rocketry. Prime contractor for the Vanguard assembly is the Glen L. Martin Company of Baltimore, Md. The first stage is said to be the first liquid-propelled rocket to have been designed without stabilizing fins or vanes. Most of the new missiles now follow this design. The saving in weight, and therefore in power needed to propel the vehicle into space, is considerable. Great economies of weight have also been made possible by using extremely thin airframes for all three stages. The first-stage engine, as a consequence, requires a thrust of only 27,000 pounds, compared with the more than 80,000 pounds for the modified Redstone used for the first stage of the Army's Jupiter-C, which launched Explorer I. Kurt R. Stehling, head of the Vanguard propulsion group, has said that the combustion efficiency of the three new rocket motors is "near the limit of the theoretically possible."

The first stage, which is 44 feet long and 45 inches across at its widest part, is a descendant of the Viking research rocket. It is manufactured by the General Electric Company. It uses kerosene for its basic fuel and liquid oxygen for oxidizing. The second stage, 31 feet long and 32 inches in diameter, is a descendant of the Aerobee research rocket and is manufactured by the Aerojet-General Corporation of Azusa, Calif. Its 7500 pounds of thrust are produced by a high-energy fuel called unsymmetrical dimethyl hydrazine and an oxidizer of white fuming nitric acid.

After the second stage burns out, it disgorges the third stage and the satellite sphere from its insides. The third stage, which is a solid-propellant rocket manufactured by the Grand Central Rocket Company, accelerates from a speed of 8500 miles per hour to one of 18,000 miles an hour. It develops 2300 pounds of thrust. When the orbiting speed is reached, a spring mechanism separates the burned out third-stage shell from the satellite.

Visual tracking. The shell—a cylinder-like object some 4 feet long and about 22 inches in diameter that weighs approximately 50 pounds—is orbiting behind the 6-inch satellite. The satellite, which circles the earth every 135 minutes, is probably too small for tracking without the aid of a telescope; however, the third stage casing may perhaps be seen with the naked eye at dawn or dusk.

Radio transmitters. The only unusual aspect of the satellite itself is the radio transmission system. One of the two transmitters carried is run by conventional mercury batteries and is designed to put out a continuous 10-milliwatt signal on a frequency of 108 megacycles for about two weeks. However, the second transmitter is operated by a group of six solar batteries distributed over the surface of the satellite in such a way that one or more always will be turned toward the sun when the sphere is on the sunny side of the earth. The satellite's path is so far from the earth that it will be in shadow for less than half of its orbit.

The solar-powered transmitter sends out a signal of 5 milliwatts on a frequency of 108.03 megacycles and is expected to operate for a long time, probably years, until cosmic dust or micrometeorites cause erosion. The solar batteries are the work of Hans K. Ziegler of the Army Signal Engineering Laboratory at Fort Monmouth, N.J., who is one of the German scientists brought to this country after World War II. He developed his battery from a solar battery produced by Bell Telephone Laboratories in 1954 that is now used to boost power on rural telephone lines.

Vanguard launching schedule. John P. Hagen, director of Project Vanguard, has announced that with the success of Vanguard I, the project has cancelled plans for firing another small test vehicle. The next satellite to be sent aloft will be a fully instrumented 21½-pound sphere. With this change in plan, Project Vanguard will attempt the launching of seven research satellites instead of the previously scheduled six.

Columbia Speeds Chemistry Ph.D.

Columbia University announced recently that it is making radical changes in the Ph.D. requirements in chemistry so that a candidate may complete postgraduate work in two years instead of the usual four or more. An accelerated program will begin in September for about 25 freshmen who have demonstrated exceptional ability in chemistry and related sciences in high school and in tests of the College Entrance Examination Board. The group will be admitted with advanced standing in chemistry and will take 144 points of credit instead of the 126 routinely required for graduation. The new program will enable the special students to begin research for the doctorate in the senior year and to eliminate lecture courses in graduate school. Thus they will achieve the Ph.D. after 4 years of college study and 2 years of graduate work.

Recommendations for U.S. Meteorology

The Committee on Meteorology of the National Academy of Sciences–National Research Council, under the chairmanship of Lloyd V. Berkner, president of Associated Universities, Inc., has released a 35-page interim report, *Research and Education in Meteorology*, which contains recommendations concerning the future of U.S. meteorological research. The most important of these recommendations is a proposal for the creation of a National Institute of Atmospheric Research.

Representatives of a dozen of the universities that are most active in meteorology have supported the Committee on Meteorology with the following resolution, which was directed to Detlev W. Bronk, president of the NAS-NRC:

RESOLVED, It is the sense of the assembled representatives of universities and kindred institutions engaged in meteorological, oceanographic, and related research and teaching, that the interim report of the Committee on Meteorology of the National Academy of Sciences be endorsed; that present support for basic research in meteorology at academic and related institutions should be substantially increased; and that a national institute for atmospheric research, operated by an association of universities, should be established to bring together scientists from meteorology and the related physical sciences and to provide research facilities on a scale required to cope with the global nature of the meteorological problem. It is further requested that appropriate organizational steps for establishing such an institute be taken immediately by the National Academy of Sciences, acting in concert with the universities and kindred institutions.

The resolution was signed by: W. A. Baum, Florida State University; R. A. Bryson, University of Wisconsin; H. R. Byers, University of Chicago; P. E. Church, University of Washington; B. Haurwitz, New York University; S. C. Hollister, Cornell University; H. G. Houghton, Massachusetts Institute of Technology; M. Neiburger, University of California, Los Angeles; H. H. Neuberger, Pennsylvania State University; S. Petterssen, American Meteorological Society; R. Revelle, Scripps Institution of Oceanography; and A. R. Kassander, University of Arizona.

Krypton-85 and Diagnosis of Heart Disease

Research at the Public Health Service's National Institutes of Health has shown that krypton-85, a radioactive form of a harmless inert gas, can be used to detect abnormal openings in the wall of muscle dividing the right and left chambers of the heart. Left to right "shunts" of blood which result from defects in the partitions of the heart are the commonest form of congenital heart disease. Accurate knowledge of the presence and location of these defects is essential for corrective surgery.

The new diagnostic technique was developed by research surgeon Richard Sanders, a staff member of the Clinic of Surgery of the National Heart Institute. The discovery was announced in the January issue of the *Proceedings of the Society for Experimental Biology and Medicine*.

Soviet Bloc IGY Plans

A weekly report of Soviet bloc activities in connection with the International Geophysical Year is being published by the U.S. Office of Technical Services. The reports contain information selected and translated from foreign-language publications regarding Soviet bloc plans and endeavors in rockets and artificial earth satellites, upper atmosphere, meteorology, oceanography, latitude, seismology, glaciology, the Antarctic, and other subjects. Non-Government scientists may subscribe to the series for $10. The series runs from 14 February 1958 to 2 January 1959. (Order PB 131632 *Soviet Bloc International Geophysical Year Information* from OTS, U.S. Department of Commerce, Washington 25, D.C. Back issues to 14 February will be supplied to subscribers regardless of the date of their order.)

Faculty Salaries

The average salary for college faculty members in the United States this year is $6120, according to the U.S. Office of Education.

A new study of higher education shows that average faculty salaries in public colleges and universities range from $5110 for instructors to $8530 for full professors; in private institutions, the average is $4230 for instructors and $7360 for full professors. The study is designed to provide basic information to assist college administrators in their planning. The 102-page report, entitled *Higher Education Planning and Management Date, 1957–58,* was prepared by W. Robert Bokelman, specialist in college business management, U.S. Office of Education.

Nearly 1150 colleges and universities, having more than 80 percent of all higher education enrollment, participated in the survey.

Salaries of full professors in the highest-paying single private university average $13,800, compared with an average of $5150 in the lowest-paying private university. The highest-paying public university had a salary average for full professors of $12,350, the lowest-paying $5750. The average salary of instructors in the highest-paying private university is $5150, compared with $3550 in the lowest-paying. The average for the highest-paying public university is $6550, compared with $3450 in the lowest-paying.

Among the lowest fourth of public universities, salaries average $7440 for full professors, $6280 for associate professors, $5460 for assistant professors, and $4410 for instructors.

The report shows that students in private colleges pay, on the average, nearly 3½ times as much in tuition and fees as most students in public colleges. Tuition and fees for resident students in public institutions average $155 for the current school year, compared with $531 in private institutions. Tuition and fees in public institutions average $13 more this year than last year, an increase of 9.2 percent. Such costs in private institutions went up $36, or 7.3 percent. In addition to salaries, and tuition and fees, the report covers other faculty benefits and room and board costs.

Copies of the publication (Circular No. 517) may be obtained for 60 cents each from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.

Atherosclerosis Findings

A reseach finding that seems to advance knowledge of coronary heart disease and other diseases associated with atherosclerosis has been reported by the laboratories of the departments of preventive medicine and pathology of the Harvard Medical School and the department of pathology of Children's Hospital, Boston. Atherosclerosis is now responsible for more deaths in the United States than any other one disease. The new approach developed at Harvard utilizes tissue-culture methods which make possible direct observation at the point where fatty substances enter cells grown from human arteries. Prior to this, the disease could be studied in the laboratory only by indirect methods, either in animals or by measuring the level of fatty substances in human blood.

Led by David D. Rutstein, head of the university's department of preventive medicine, the group of investigators say that they have observed the deposit of these fatty substances in arterial cells. More important, they maintain that they have also demonstrated that the process is reversible and can either be prevented with unsaturated fatty acids or aggravated with saturated fatty acids.

The new research results are published in the current issue of the British medical journal *Lancet*. Rutstein's associates are Estelle Fasolino Ingenito, research associate in preventive medicine; John M. Craig, assistant professor of pathology; and Marcello Martinelli, Lederle research fellow in preventive medicine from the University of Bologna, Italy.

Nomenclature of Cell Strains

At the International Tissue Culture Meeting, held in Glasgow, Scotland, last summer, the subject of the nomenclature of cell-strains used in tissue culture was considered and a study committee was appointed that made various recommendations. It was suggested that the following information be given when first

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mention of a cell strain is given in a publication: (i) whether the tissue of origin was normal or neoplastic and, if neoplastic, whether benign or malignant; (ii) whether the tissue was adult or embryonic; (iii) animal species of origin; (iv) organ of origin; (v) the cell type (if known); (vi) the designation of the strain; (vii) whether the strain has been cloned and, if so, the clone number; and (viii) the reference to the original article in which the strain was described. It was further suggested that the designation of the strain should consist of a series of not more than four letters indicating the laboratory of origin, followed by a series of numbers indicating the strain.

Markle Scholars

The John and Mary R. Markle Foundation has announced the appointment of 25 scholars in medical science, all faculty members of medical schools in the United States and Canada. The sum of $750,000 has been appropriated toward their support at the schools where they will teach and conduct research. For each scholar appointed, the foundation has allocated $30,000 to the school at the rate of $6000 a year for 5 years.

The 25 scholars who received the appointments were selected from 57 candidates nominated by medical school deans. Five committees of laymen helped to select the scholars through extended interviews over 3-day periods. This year's Markle scholars are: Murray N. Andersen, associate in surgery, University of Buffalo School of Medicine; Neil R. Burch, assistant professor of psychiatry, Baylor University College of Medicine; William R. Drucker, assistant professor of surgery, Western Reserve University School of Medicine; Richard H. Egdahl, instructor in surgery, Medical College of Virginia; David Hamerman, assistant professor of internal medicine, Albert Einstein College of Medicine; Harold F. Hardman, instructor in pharmacology, University of Michigan Medical School; Robert F. Hetherington, assistant professor of neurological surgery, Queen's University Faculty of Medicine (Canada); Eugene A. Hildreth, assistant professor, internal medicine, University of Pennsylvania School of Medicine; Walter Hollander, Jr., assistant professor, internal medicine, University of North Carolina School of Medicine; Gerald H. Holman, assistant professor of pediatrics, University of Saskatchewan College of Medicine (Canada); James P. Isaacs, instructor in surgery, Johns Hopkins University School of Medicine; Robert B. Jennings, assistant professor of pathology, Northwestern University Medical School; Thomas Killip, assistant professor, internal medicine, Cornell University Medical College; Jack Wayne Love, instructor in physiology, Yale University School of Medicine; James V. Maloney, Jr., assistant professor of surgery, University of California School of Medicine; Lionel E. McLeod, lecturer in internal medicine, University of Alberta Faculty of Medicine (Canada); Rene B. Menguy, instructor in surgery, University of Oklahoma School of Medicine; Robert L. Metzenberg, Jr., assistant professor of biochemistry, University of Wisconsin Medical School; Donough O'Brien, assistant professor of pediatrics, University of Colorado School of Medicine; Guy Owens, assistant professor of neurosurgery, Vanderbilt University School of Medicine; Ned W. Smull, instructor in pediatrics, University of Kansas School of Medicine; Gerald B. Spurr, assistant professor of physiology, University of Tennessee College of Medicine; Donald P. Swartz, lecturer in obstetrics and gynecology, University of Western Ontario Faculty of Medicine (Canada); Ullrich Georg Trendelenburg, associate in pharmacology, Harvard Medical School; William L. Weirich, instructor in surgery, University of California School of Medicine, San Francisco.

Committee on Effects of Radiation

The 15-member United Nations Scientific Committee on the Effects of Atomic Raditaion recently completed a 5-week session during which it considered a basic draft of a comprehensive report to the U.N. General Assembly, scheduled for transmission to member states in mid-1958. The draft as now formulated will be put into document form and sent by the Secretariat to committee members for further study. The committee will meet again in June for review and approval of the report before it is presented to the Secretary-General for transmission to the members of the United Nations.

The report will deal with the effects of atomic radiation, including the natural background radiation always present, artificial radiation from medical applications and other peaceful uses of atomic energy, and fallout resulting from nuclear weapon tests. It will be concerned both with the immediate effects on man and his environment and with long-range effects on future generations.

It has been based on study of some 180 reports submitted by 30 governments, by four United Nations specialized agencies (the Food and Agriculture Organization; the United Nations Educational, Scientific and Cultural Organization; the World Health Organization; and the World Meteorological Organization), and jointly by the International Commission on Radiolog l Protection and the International mmission on Radiological Units and easurements.

The session just ended s the fourth held by the committee. e three previous sessions considered pecific problems, including measurem ts of natural and man-made sources of adiation, the effects of small doses of adiation, possible hazards in medical ses of radiation, the extent and effects of radioactive fallout, the contamination from atomic energy installations (including nuclear power plants), and the long-range genetic effects of radiation. At the beginning of the fourth session the committee first considered one other specific subject, the somatic effects of radiation (effects limited to the individual and not passed on to descendants). It then began formulating the draft report as a whole.

The committee is composed of scientists named by Argentina, Australia, Belgium, Brazil, Canada, Czechoslovakia, Egypt, France, India, Japan, Mexico, Sweden, the U.S.S.R., the United Kingdom, and the United States. Zenon Bacq of Belgium is chairman, and E. A. Watkinson of Canada is vice chairman.

Darwin Centennial Celebration

The University of Chicago will sponsor a celebration of the 100th anniversary of the publication of Darwin's *Origin of Species* from 18 to 24 November 1959. With aid from the National Science Foundation, and with the cooperation of the Chicago Natural History Museum and of national scientific societies, the celebration will bring together leading figures in the sciences from all over Europe and America.

The core of the celebration will be 5 days of conferences to discuss invited papers, which will later be published in a volume, possibly with some discussion. In addition to the 40 scientists whose papers will be discussed, about 500 to 1000 visitors are expected to attend. Scientists from abroad who have already agreed to participate include: Sir Charles Darwin, Cambridge, England; Sir Julian Huxley, London; E. B. Ford, director of the Genetics Laboratory, Oxford University, Oxford, England; C. D. Waddington, professor at the Institute of Animal Genetics, Edinburgh, Scotland; G. F. Gause, professor at the Institute of Antibiotics, Academy of Medical Sciences, Moscow; N. Tinbergen, lecturer on animal behavior, Oxford University; François Bordes, professor of archeology and prehistory, University of Bordeaux, Bordeaux, France; Fred Polak, head of the department of social relations, University of Rotterdam, Rotterdam, Netherlands; and MacDonald Critchley, chief physician, National Hospital, London.

Tax Concession to Encourage Basic Research

Representative Richard M. Simpson (R.-Pa.) and Representative Thomas B. Curtis (R.-Mo.), members of the tax-writing House Committee on Ways and Means, have announced the joint sponsorship of identical bills to amend the Internal Revenue Code so as to "encourage basic research in science by the allowance of a tax credit for contributions and other expenditures for basic research in science." The bill would provide a tax concession for contributions for basic research to universities and nonprofit organizations, as well as a tax concession to industries that conduct basic research.

The concession in the case of contributions would take the form of a tax credit of 90 percent of the contributions made, with a further limitation that the credit may not exceed 5 percent of the tax. In the case of basic research activity by industry, the credit would be limited to 75 percent of the expenditures, with the limitation that the credit not exceed 3 percent of the tax. The cosponsors of this legislation have indicated that the proposed amendments to the Internal Revenue Code would give effect to the National Science Foundation recommendation to increase basic research that was contained in the NSF *Report to the President on Basic Research* of October 1957.

Industrial Development of Reactors

The U.S. atomic industry during 1957 completed the construction of 16 nuclear reactors, including seven power-type reactors and nine reactors for research and test purposes. Of the seven power-type reactors, one is a privately owned power-producing reactor, four are prototype power plants built for the U.S. Atomic Energy Commission, and two are for the propulsion of naval submarines. Of the nine research and test reactors, six are located abroad, one is privately owned in the U.S., and two are owned by the AEC.

In addition to the completed reactors, U.S. industry during the year had 59 reactors under construction, 35 of which are power–type reactors, 24 research and test reactors. Of the 35 power–type reactors, 28 are reactors or reactor prototypes for the propulsion of naval vessels, four are power reactors for private U.S. owners, one is a power reactor for export, one is a power prototype to be owned by the AEC, and one is for the propulsion of a merchant ship which will be owned by the U.S. Government. Of the 24 research and test reactors, 13 are for export, six are for ownership by the U.S. Government, and five are for private U.S. buyers.

During the year industry also received contracts for the construction of 10 additional reactors, including two power reactors for private U.S. owners, one power reactor for ownership by the AEC and operation by a local government organization, one power reactor for export, one prototype reactor for the propulsion of naval vessels, three research and test reactors for export, and two research reactors for private U.S. buyers.

These are in addition to 28 small research, training, and exhibit reactors that were built or under construction by U.S. industry during 1957 for purchasers in the U.S. and abroad. (The totals given here do not include reactors being constructed or completed by Atomic Energy Commission Laboratories.)

Population

Population growth in the United States continued at a record level during 1957, amounting to about 3 million persons, according to estimates recently completed by the Bureau of the Census, Department of Commerce. There were an estimated 172,790,000 persons in our population at the beginning of this year, compared with 169,800,000 a year earlier. For the second year in succession, population growth was approximately 3 million. In each year since 1947 population growth has exceeded 2½ million and the rate of increase has approximated 1.7 percent. In the 8-year period since the beginning of this decade the increase in population exceeded 22 million, a population gain 3¼ million greater than that which occurred during the entire 1940 decade.

The sustained high level of births has been the primary factor in the continued rapid growth of the population. There were 4,302,000 babies born in 1957, the largest number on record. About 32 million babies have been born during the past 8 years, or more than the total number born in the whole decade of the 1940's.

News Briefs

Japan is establishing a central documentation center for science and technology. It will have its headquarters in Tokyo and will be known as the Japan Information Center of Science and Technology. A semi-official organization, it will be supported both by government and private funds.

* * *

The American Medical Association has announced that it will soon publish a new, 16-page tabloid newspaper called the *A.M.A. News* that will be distributed every 2 weeks to approximately 200,000 physicians. The first issue is expected to be ready for release at the annual A.M.A. convention in San Francisco, 23–27 June.

* * *

Argonne National Laboratory has been authorized by the Atomic Energy Commission to construct a Fuels Technology Center at the laboratory site, near Lemont, Ill. The new center is expected to cost about $10 million.

* * *

The governing body of the World Health Organization, the World Health Assembly, will hold its 11th session beginning 28 May in Minneapolis, Minn., on the invitation of the U.S. Government and the city of Minneapolis. The meeting is expected to last 3 weeks. The World Health Assembly, composed of delegations from WHO's 88 member states, decides the organization's policies, program, and budget. It is not a conference or a convention but a business meeting that makes the decisions necessary for continuing the organization's work.

* * *

The Max Planck Institute for Physics of the Stratosphere and Ionosphere in Lindau, Kreis Northeim, Germany, has been renamed the Max Planck Institute for Aeronomy (Max-Planck-Institut für Aeronomie).

* * *

A translation of a report on Russia's 5-year plan for research in pharmacology is available at the National Institutes of Health. The report cites successes attained in pharmacologic research during the period 1950–55 and discusses expectations for the period 1956–1960. Copies of the translation, *Problems Involved in Five-Year Plan for Research in Pharmacology for 1956–1960,* are available from the Publications and Reports Section of the Scientific Reports Branch, National Institutes of Health, Bethesda 14, Md.

* * *

Polish scientists have prepared twilight tables to the year 2020 as a contribution to the International Geophysical Year. The tables provide a means for calculating the interval during which the atmosphere is illuminated after sunset and before sunrise. The tables are continuations of earlier ones prepared in Poland in 1932–34. They have been published under the auspices of the Polish Academy of Sciences and are accompanied by explanations in English, French, Russian and Spanish.

* * *

Non–Conventional Technical Information Systems in Current Use is a new report, prepared by the National Science Foundation's Office of Scientific Information, that describes 25 representative

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technical information systems of new design—some manually operated and some mechanized. Of the systems covered, the majority are found within the chemical industry. Copies of the report may be obtained by writing to the National Science Foundation, Washington 25, D.C.

Proposed Legislation

S 2916. Provide for grants to states to assist them to increase salaries of teachers of science in secondary schools and provide necessary equipment to use in connection with instruction of scientific subjects in such schools. Thye (R-Minn.). Senate Labor and Public Welfare.

S 2917. Promote general welfare of U.S. by providing program of scholarships for college undergraduate and graduate level education to be administered by Commissioner of Education. Thye (R-Minn.). Senate Labor and Public Welfare.

S 2956. Amend Vocational Education Act of 1946 to promote scientific education. Monroney (D-Okla.), Kerr (D-Okla.), McNamara (D-Mich.). Senate Labor and Public Welfare.

S 2957. Advance national security and welfare; promote progress of science by establishment of a U.S. Science Academy. Thurmond (D-S.C.). Senate Labor and Public Welfare.

S 2967. Provide for establishment of National Science Academy, a program of scientific scholarships; encourage study of mathematics and science by assisting States in providing science education. Gore (D-Tenn.). Senate Labor and Public Welfare.

HR 9620. Amend P.L. 874, 81st Congress, re assistance for maintenance and operation of schools in federally impacted areas, extend its effectiveness for two additional years. Auchincloss (R-N.J.). House Education and Labor.

HR 9634. Expedite utilization of television facilities in our public schools and colleges, and in adult training programs. Boggs (D-La.). House Education and Labor.

HR 9635. Provide for establishment of national program of science scholarships; provide for establishment of a program of loans to educational institutions to aid in providing adequate science facilities. Brooks (D-Tex.). House Education and Labor.

HR 9692. Provide for a scholarship program to aid in maintaining and strengthening U.S. leadership in certain fields of science and technology. Martin (R-Mass.). House Education and Labor.

HR 9830. Authorize appropriation of funds to assist States and Territories in financing a minimum foundation education program of public elementary and secondary schools, and in reducing inequalities of educational opportunities through public elementary and secondary schools, for general welfare. Perkins (D-Ky.). House Education and Labor.

HR 9905. Authorize Secretary of Defense to grant scholarships and fellowships in scientific fields to promote defense and security of U.S. Dingell (D-Mich.). House Armed Services.

S 2994. Provide for holding a White House Conference on Aging to be called by President of U.S. before 31 December 1958, to be planned and conducted by Special Staff on Aging of the U.S. Department of Health, Education and Welfare with assistance and cooperation of other agencies of that department and of other departments and agencies represented on Federal Council of Aging; assist several states in conducting similar conferences on aging prior to White House Conference on Aging. Neuberger (D-Ore.), Kefauver (D-Tenn.). Senate Labor and Public Welfare.

Scientists in the News

ARTHUR W. MARTIN has been named program director for regulatory biology, Division of Biological and Medical Sciences, National Science Foundation. He is on leave of absence from the University of Washington, where he is professor and executive officer, department of zoology. Martin has done extensive research in physiology: cellular metabolism, muscle atrophy in mammals, blood circulation in fish, excretory processes in mollusks, and pharmacological actions of barbiturates and their antagonists.

G. B. KISTIAKOWSKY, Russian-born physical chemist who is chairman of the department of chemistry at Harvard University and a leader in the development of long-range missile propellants, has received Dickinson College's Priestley Memorial Award. The award, a Wedgewood medallion of Priestley and $1000, is conferred each year upon a scientist for research, discovery, or production benefiting mankind.

C. N. YANG of the Institute for Advanced Study, Princeton, N.J., and 1957 Nobel prize winner in physics, and JULIAN SCHWINGER of Harvard University will spend this summer at the University of Wisconsin as members of the physics staff.

ALBERT C. ZETTLEMOYER, professor of chemistry at Lehigh University and director of the National Printing Ink Research Institute, will discuss "Molecular Interactions with the Surfaces of Solids" as a Sigma Xi national lecturer at a number of colleges and universities during April and May. Another Sigma Xi lecturer for the period is JOSEPH W. BEARD of Duke University School of Medicine, whose subject will be "Viruses as a Cause of Cancer."

BARRY G. KING, formerly research executive of the Medical Division, Civil Aeronautics Administration, has been named vice president, life sciences, at Operations Research Incorporated, Silver Spring, Md.

WILLIAM F. ASHE, chairman of the department of preventive medicine at the Ohio State University College of Medicine, has been named director of a 10-member team of U.S. specialists to conduct a nutrition survey in Spain at the request of the Spanish government. The survey, which will be made this spring, is the seventh of its kind to be conducted under the supervision of the Interdepartmental Committee on Nutrition for National Defense in cooperation with nations of the free world as part of the U.S. technical assistance program. The ICNND is a federal agency whose membership includes the departments of State, Defense, Agriculture, and Health, Education and Welfare; the International Cooperation Administration; and the Atomic Energy Commission.

FRANK P. McWHORTER, plant pathologist of Oregon State College, has been appointed by the Food and Agriculture Organization of the United Nations to serve as virologist to the Philippine Government to investigate the Cadang Cadang disease of coconuts. Cadang Cadang is a serious virus-like disease of unknown cause. McWhorter has had more than 25 years of experience in the study of virus diseases in Oregon and the Northwest, and in addition has made a 3-year study of plant diseases in the Philippines. His address beginning in April will be United Nations Building, Manila.

WILLIAM W. WILLMARTH, senior reseach fellow at California Institute of Technology and consultant to the Rand Corporation, Santa Monica, Calif., has been appointed associate professor of aeronautical engineering at the University of Michigan.

ALEXANDER SILVERMAN, professor emeritus of the University of Pittsburgh, has received the eleventh Albert Victor Bleininger Memorial Award of the Pittsburgh section of the American Ceramic Society. Silverman, noted as an educator and an international authority on the chemistry of glass, is being honored for his contributions to the ceramic industry.

SAM [illegible] SMITH has been appointed associate director for the biological sciences for the Research Corporation, New York. Smith, who joined the nonprofit philanthropic foundation in 1955, will be associated with the organization's Brown–Hazen Fund. He will also continue in his present position as secretary of the Williams–Waterman Fund.

The Williams–Waterman Fund—which gets its money from patents on the synthesis of Vitamin B_1—makes grants for research in nutrition. The Brown–Hazen Fund was established in May 1957 to support fundamental research in biochemistry, microbiology, and immunology. The fund receives its income from royalties on the production of nystatin, the antifungal antibiotic discovered and developed by ELIZABETH L. HAZEN and RACHEL BROWN of the scientific staff of the New York State Laboratory.

JOHN G. LUDWICK, JR., sedimentologist, Gulf Research and Development Company, Harmarville, Pa., and WILLIAM R. WALTON, geologist, Pan American Petroleum Company, Tulsa, Okla., have received the president's award of the American Association of Petroleum Geologists for their article, "Shelf-Edge, Calcareous Prominences in the Northeast Gulf of Mexico," which appeared in the September 1957 issue of the association's *Bulletin*. The $100 award is given annually to the author, or authors, under the age of 35, whose article in the *Bulletin* of the preceding year is considered the most significant contribution to petroleum geology.

JOHN M. HOWARD has been appointed professor and head of the department of surgery at Hahnemann Medical College. He succeeds WILLIAM H. MARTIN, who retires at the close of the 1958 academic year after 16 years as professor of surgery. Howard was formerly Joseph Brown Whitehead professor of surgery and chairman of the department of surgery at Emory University School of Medicine.

ALVIN F. COBURN has been appointed director of clinical investigation for the Laboratories for Pharmaceutical Development, Yonkers, N.Y. Coburn is known for his role in the demonstration of the relationship between an antecedent beta hemolytic streptococcal respiratory infection and rheumatic fever. He is a former member of the faculty of Northwestern University Medical School, where he founded and was director of the Rheumatic Fever Research Institute from 1947 to 1957. In addition to his new post, Coburn will continue to serve as associate professor of pediatrics at the New York Medical College.

GEORGE R. NAGAMATSU, known for research in surgery of the kidneys, has been appointed director of the department of urology, New York Medical College.

CHARLES H. STAUFFER has arrived at St. Lawrence University, Canton, N.Y., to assume his duties as professor of chemistry and head of the university's chemistry department. He replaces WARREN LUX, who resigned to accept a position with Union Carbide Corporation in New York. Stauffer was a member of the Worcester Polytechnic Institute faculty for 20 years, and at the time of his resignation held the rank of associate professor.

FRED. J. EMMERICH, past chairman of the board of directors of Allied Chemical & Dye Corporation, New York, has been chosen to receive the Chemical Industry Medal for 1958 "for conspicuous services to applied chemistry." Announcement of the award was made by the American Section of the Society of Chemical Industry, donor of the medal. Formal presentation to Emmerich will be made at a meeting of the American Section following a dinner in the medallist's honor at the Royal York Hotel, Toronto, Ontario, on 18 September. The medal presentation will be the American Section's principal part in the annual meeting of the whole Society of Chemical Industry as guest of its Canadian Section.

The department of ophthalmology of the New York University–Bellevue Medical Center has appointed GOODWIN M. BREININ to the first Daniel B. Kirby professorship of research ophthalmology. Breinin is at present director of research in the department of ophthalmology at the New York University Post-Graduate Medical School, a position which he will continue to fill. His primary field of interest has been electrophysiology of the eye, with particular reference to the extraocular muscles. He has applied electronic engineering principles to neuromuscular problems of the eye and so has opened new avenues of approach to the diagnosis and treatment of strabismus.

The Department of Commerce Gold Medal has been presented to ERLE L. HARDY of the Weather Bureau's Regional Headquarters at Ft. Worth, Tex. Hardy was honored for his outstanding contribution to the public service in the organization of hurricane preparedness plans and for his contributions to effective management as demonstrated during a special assignment to the Weather Bureau's National Weather Records Center at Asheville, N.C.

H. J. ROGERS of the bacterial physiology division, National Institute for Medical Research (Medical Research Council), London, England, arrived in the United States in mid-March to work for 3 months in the laboratory of A. Dorfman, department of pediatrics, University of Chicago.

J. T. PATTERSON, professor emeritus of zoology at the University of Texas, has been elected an honorary member of the Genetics Society of Japan.

The U.S. Public Health Service has announced the appointment of ARNOLD B. KURLANDER to the newly created post of Assistant Surgeon General for Operations. For the past 11 months Kurlander has been serving as an assistant to Surgeon General Leroy E. Burney. A career officer of the Public Health Service, Kurlander was formerly chief of the chronic disease program.

WALTER WASSON, Denver, Colo., radiologist, was awarded the gold medal of the American College of Radiology at special ceremonies in connection with the organization's 35th annual meeting in Chicago. The award, only the 18th in the nearly 40-year history of the college, is presented for outstanding contributions in radiology.

JAMES A. REYNIERS, research professor of bacteriology at the University of Notre Dame, and founder and former director of the university's Lobund Institute, will resign on 9 January 1959. During the interim period he will continue his research at Notre Dame on germ-free life.

Recent Deaths

GEORGE BRYAN, Madison, Wis.; 78; emeritus professor of botany at the University of Wisconsin; author of *Textbook of General Botany*; 7 Mar.

JOHN J. DEMPSEY, Washington, D.C.; 78; member of the U.S. House of Representatives (D-N.M.) who had served on the Joint Committee on Atomic Energy; 11 Mar.

ALFRED GUNDERSEN, Venice, Fla.; 80; for many years curator of plants at the Brooklyn Botanic Garden; specialist in the evolution of the flowering plants; 21 Feb.

HENRY B. McDONNELL, College Park, Md.; 94; physician, chemist, emeritus dean of natural sciences at the University of Maryland; 7 Feb.

JOHN B. WHITNEY, Upper Montclair, N.J.; 76; retired chemical engineer; specialist in the design, construction and operation of sulfuric acid plants; 12 Mar.

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Book Reviews

Science and the Social Studies. 1956–57, twenty-seventh yearbook. Howard H. Cummings, Ed. National Council for the Social Studies, Washington, D.C., 1957. 271 pp. Cloth, $5; paper, $4.

It has apparently been intended that this yearbook should be read by high-school teachers of the social studies. The authors, 13 in number, contribute in varying degree to the development of two themes: (i) that advances in science and in technology have caused constantly accelerating changes in social, economic, and political conditions; and (ii) that teachers of social studies must assume greater responsibility for teaching pupils to make intelligent adjustments to these changes.

In the development of the second of these themes it is conceded that the teacher of social studies must have some understanding of science and of the ways in which scientists work. Taking a cue from James B. Conant, several of the authors propose that such an understanding be developed through the "case study" approach. Presumably to provide the teacher of social studies with ideas and with material for such case studies, as well as for the amplification of theme number one, parts I and II of the yearbook present a series of chapters having to do with the present effort to apply science and technology for the improvement of underdeveloped countries and with the International Geophysical Year, the work of the National Science Foundation, and the results of recent research in agriculture, in medicine, and in the use of radioisotopes. These chapters have been prepared by writers who appear to have ample technical knowledge in their respective fields. The chapters should prove to be useful as sources of reference material, not only for teachers of social studies but for all who are interested in progress in the applied sciences.

In part III there is an attempt to indicate ways in which teaching in the sciences or in the social studies may be organized to give greater emphasis to some of the methods used by the scientist and to the development of better understanding of the social consequences of scientific discovery. These chapters are well written but appear to present few ideas which have not already been well developed by the same authors, as well as by others, in publications which have been generally available for several years.

As might be expected where there are so many authors involved, the sections and the chapters of the yearbook vary considerably in style, and the continuity between divisions is sometimes not too apparent. However, there can be no doubt that scientists, social scientists, teachers, and the public all need to give greater attention to the need for constructive utilization of the processes and products of scientific discovery. The yearbook is, therefore, timely and may provide a needed inspiration for its readers.

HAROLD E. WISE

Graduate College,
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Physics and Chemistry of the Earth. vol. 2. L. H. Ahrens, Frank Press, Kalervo Rankama and S. K. Runcorn, Eds. Pergamon, New York and London, 1957. viii + 259 pp. Illus. $10.

This is the second volume of *Physics and Chemistry of the Earth.* Volume 1 was reviewed in *Science,* last May [**125**, 891 (1957)]. This volume is just as substantial as the earlier volume, though it contains fewer pages and one less chapter.

William S. von Arx of Woods Hole Oceanographic Institute describes "An experimental approach to problems in physical oceanography," using laboratory models as analogues to study marine circulation. He details the theoretical considerations and operating practices which serve as guides in the construction of three types of models: small inshore areas, marginal and mediterranean seas and some large lakes, and planetary models. Natural circulations can be duplicated in models, and some of the as-yet-unexplained features of ocean currents also appear. The planetary model develops unusual patterns of circulation in parts of the oceans that have not been explored oceanographically and invites field inspection.

L. H. Ahrens presents "A survey of the quality of some of the principal abundance data of geochemistry." Individual determinations by any method may be disappointing, and it is generally laborious to measure precision. Constituents in low concentration are most subject to error and, unfortunately, these errors profoundly affect geochemical conclusions regarding trace elements. Neutron activation and isotope dilution-mass spectrometric determinations may give us very accurately analyzed materials to use as standards for more conventional methods.

Harold C. Urey discusses "Boundary conditions for theories of the origin of the solar system." The interrelationships considered are: temperature during origin, temperature at later times, volatility, density variations among planets, chemical and physical processes producing differences in proportions of metallic and silicate phases in different planets, structure and composition of meteorites, and the occurrence of iron as the element, the oxide, and the sulfide. He emphasizes the importance of solid bodies and of the physical and chemical processes to which they were subjected. Urey urges that the possibility that the solids rather than the gases dominated the processes by which the solar system originated be more seriously considered in astronomical theories.

Francis A. Richards reviews "Some current aspects of chemical oceanography." Analysis of so complex a solution as sea water is exacting, and shipboard conditions compound the difficulties. There is great need for improved analytical techniques. The discussion of major and minor constituents, dissolved gases, biochemical relationships, and nutrients and their distribution and consumption are interesting in themselves and, above all, highlight the interdependence of the many disciplines that contribute to oceanography.

M. N. Hill, in describing and evaluating the "Recent geophysical exploration of the sea floor," leads the reader to feel that gravimetric, magnetic, refraction shooting, reflection shooting, heat-flow, and surface-wave dispersion measurements need support from each other to give more than a partial picture. For those restricted parts of the sea floor which have been explored, the four-layer structure down to the Mohorovicic discontinuity is reasonably uniform: unconsolidated sediments, consolidated sediments or volcanic rocks, basic igneous (basaltic) rocks, and deep basement (ultrabasic) rocks. Geophysical and geological study of atolls and volcanic islands lends more support to crustal subsidence than to eustatic changes for explaining the sinking with respect to sea level.

Denis M. Shaw reports on "The geochemistry of thallium, indium, thallium." The history, chemistry, and cosmic abundance are discussed, then the geochemistry of each is separately reviewed. Outstanding problems needing investigation are summarized: geochemical affinities and cosmic distribution as deduced from meteorites; occurrence in sulfides; precise analyses aimed toward investigating the perplexing tin-indium association; and greater analytical sensitivity for restudy of distribution of indium in silicates. The association of thallium and manganese in sediments needs confirmation.

P. J. Melchior reviews "Latitude variation." He makes very clear the importance and difficulty of the observational procedures and the enormous patience and care of the International Latitude Service. The maximum diameter of the curve described by the instantaneous pole observed since 1900 is about 0.7 second, corresponding to a displacement of 21 meters on the earth's surface. The variations of latitude determined by astronomical observations contribute to problems involving elastic deformations of the earth, secular displacement of the mean pole, and some of the dynamical properties of a liquid core.

Volume 2 has subject index and name index, and each chapter has many references. The careful study of this book pays large dividends in broadened horizons.

WILLIAM R. THURSTON
National Academy of Sciences–National Research Council

Natürliche und Künstliche Erbänderungen. Probleme der mutationsforschung. Hans Marquardt. Rohwolt, Hamburg, Germany, 1957. 177 pp. Illus. Paper.

Radiation genetics is, at the moment, in a strange situation. There is, on one hand, a great general interest in the effects of atomic radiations on our hereditary substance, and there exist, on the other hand, no manuals or textbooks to inform the public, or members of the medical profession, biologists, radiobiologists, and physicists, of the present stage of mutation research. To bridge the gap, H. Marquardt, professor of forest-botany at the University of Freiburg (Breisgau, Germany), presents in this little booklet (No. 43 of Rohwolt's *Deutsche Enzyklopädie*), in five chapters, a well-rounded picture of the existing situation, tying the principal experimental facts of mutation research into a unit with the logical conclusions and consequences. There is a short survey of the historical development, followed by chapters that deal, respectively, with the cytological foundations, the genetic foundations, the mutation process, and the importance of modern mutation research for our technical age.

The book is written in a clear, pleasant, and musical diction—Marquardt holds, besides his Ph.D. in biology, a doctor's degree in music—and reads like a thrilling report on an expedition in unknown territories. It is surprising how much—by proper arrangement of the facts—can be said in such a small volume. The book will definitely fill a present need and will be welcomed in wide circles; only the language barrier will limit its use.

A. T. KREBS
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Climatology. Treated mainly in relation to distribution in time and space. W. G. Kendrew. Oxford University Press, New York, ed. 2, 1957. xv + 400 pp. Illus. + plates. $6.75.

Although this is a revision of the first edition, published in 1949, it is essentially a moderately altered edition of *Climate,* published in 1930, which contained most of the material of the present edition. Numerous small changes have been made, and a few new paragraphs have been added, together with an inadequate bibliography, mostly of British publications.

This volume was written "for the general reader" and affords brief statements about numerous aspects of climate, with, however, few explanations of the causes for the local differences. Part 1 (10 chapters) concerns insolation and temperature; part 2 (7 chapters) deals with atmospheric pressure and winds; part 3 (11 chapters) deals with atmospheric vapor and its condensation and also with sunshine and visibility. Mountain climates are discussed in part 4 (5 chapters), and the "weather of the westerlies" is covered in part 5 (5 chapters). The final part (3 chapters) is called "Some climatic types."

In addition to illustrations of the conventional aspects of climate there are brief discussions of smog, fronts, periodicities, hail, tornadoes, and hurricanes. The presentation is formal or "heavy." The examples are largely from the British Isles or from British colonies or ex-colonies. This volume is not suitable as a text, nor is it one of the better popular treatments of the subject.

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The Pigeon. Wendell Mitchell Levi. Levi Publishing Company, Sumter, S.C., 1957. xxvii + 667 pp. Illus. $20.

Biologists, psychologists, and others who study the pigeon have made good use of the first edition of this book, and the second edition carries them further into W. M. Levi's debt. An enormous amount of information is brought together from the most diverse sources. Much of it, particularly the discussions of breeding, housing, care, and diseases, is of great practical value to those studying the pigeon in laboratory or loft. The beautifully illustrated sections on the history and varieties of pigeons are of more general interest. The sections on anatomy, physiology, genetics, and behavior could not, in the nature of the book, be complete, but they are useful accounts for the nonspecialist. The section on commercial squab production, though of no immediate scientific interest, is written with special authority. There are delightful miscellanies scattered through the text. Among the 1127 illustrations the reader will find pictures of Old English dovecotes, Egyptian-style multiple lofts, bells attached to the feet of pigeons in Bali, and a set of 15 perfectly tuned pipes once sewn to the tail feathers of a pigeon in Peking.

So ambitious an undertaking is bound to have an occasional blemish (the index is not fully adequate, for example), but the book is, nevertheless, a landmark in the literature on the pigeon. Beyond that, it is an achievement of a dedicated layman (Levi, though he served in a Pigeon Section of the Signal Corps in World War I and has been an officer in many organizations concerned with pigeons, is a lawyer) which might put many a professional scientist to shame.

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Die Periphere Innervation. Emil Villiger. Schwabe, Basel, Switzerland, ed. 11, 1957. 210 pp. Illus. $5.

This book on the peripheral nervous system is the companion volume to Emil Villiger's well-known text on the anatomy of the brain and spinal cord. After ten years it now reappears in its eleventh edition, attesting to its perennial popularity. Since Professor Villiger's death, both volumes have been taken over and revised by his successor, Eugen Ludwig, presently professor emeritus of anatomy at the University of Basel.

Die Periphere Innervation begins with a completely new chapter on the general characteristics of peripheral nerves, including data on their ultrastructure as

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revealed by the electron microscope, anastomotic fiber patterns, and the fiber spectra of nerves and nerve roots. The author next takes up the pattern and divisions of the spinal nerves and their connections with the peripheral, sympathetic, and central nervous systems. This is followed by detailed descriptions of the spinal nerves considered individually, their plexuses, and their sensory or motor destinations. This section includes useful summaries for quick reference, as well as tables of motor functions. In the succeeding chapter, the cranial nerves are considered in comparable detail, and information is given about their central origin and their peripheral interconnections and functions. Another chapter deals with the autonomic nervous system as a whole, in particular with the sympathetic innervation of the viscera, and reviews the autonomic contribution to the somatic nerves and the parasympathetic innervation of the head. There follows a brief chapter on the central pathways involved in perception and in reflex and voluntary movement. This is strictly traditional in viewpoint, naturally oversimplifying somewhat, and serves as an introduction to the book's final section, which relates neurological symptoms—paralytic, irritative, and release phenomena—to their anatomical substrate and describes the clinical picture of lesions of the spinal and cranial nerves.

The book is illustrated with clinical photographs as well as with a series of line drawings which are models of clarity and good draftsmanship. One might have wished for some consideration of peripheral sensory receptors, and for more attention to the alpha and gamma spinal efferent systems in view of their increasing physiological importance. Likewise, the absence of a bibliography will handicap the research worker. Nonetheless, this is an excellent and authoritative text for the medical student, practitioner, or specialist, although it is only fair to point out that much of this material is included in general textbooks of anatomy.

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New Books

X-Ray Microscopy and Microradiography. Proceedings of a symposium held at the Cavendish Laboratory, Cambridge, 1956. V. E. Cosslett, Arne Engstrom, H. H. Pattee, Jr. Academic Press, New York, 1957. 663 pp. $16.50.

Principles of Ophthalmoscopy. John K. Erbaugh. Thomas, Springfield, Ill., 1958. 79 pp. $5.50.

Biographical Memoirs of Fellows of the Royal Society. vol. 3. Royal Society, London, 1957. 328 pp. 30s.

Les Méthodes Nouvelles de la Mécanique Céleste. vol. I, *Solutions Périodiques*; Non-existence des intégrales uniformes, solutions asymptotiques; vol. II, *Méthodes de MM. Newcomb, Gyldén, Lindstedt et Bohlin*; vol. III, *Invariants Intégraux*: Solutions périodiques du deuxième genre, solutions doublement asymptotiques. H. Poincaré. Dover, New York, 1957 (unabridged and unaltered republication of the volumes originally published in 1892, 1893, and 1899). 382 pp.; 479 pp.; 414 pp. $2.75 each; set, $7.35.

Annual Report of the Board of Regents of the Smithsonian Institution. For the year ended 30 June 1956. Publ. 4272. Smithsonian Institution, Washington, D.C., 1957 (Order from Supt. of Documents, GPO, Washington 25). 580 pp. $4.50.

Organic Colloids. Bruno Jirgensons. Elsevier, Princeton, N.J., 1958. 669 pp. $16.75.

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Treatise on Marine Ecology and Paleoecology. vol. 1. *Ecology*. Geological Society of America Memoir 67. Joel W. Hedgpeth, Ed. Geological Society of America, New York, 1957. 1304 pp. $12.50.

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Method and Theory in American Archaeology. Gordon R. Willey and Philip Phillips. University of Chicago Press, Chicago, 1958. 278 pp. $4.75.

Only a Trillion. Isaac Asimov. Abelard-Schuman, New York, 1957. 195 pp. $3.50.

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An Introduction to Chemical Thermodynamics. E. F. Caldin. Clarenden Press, Oxford, 1958 (order from Oxford University Press, New York). 439 pp. $8.

An Introduction to the Foundations and Fundamental Concepts of Mathematics. Howard Eves and Carroll V. Newsom. Rinehart, New York, 1958. 378 pp. $6.75.

Basic Animal Husbandry. John M. Kays. Prentice-Hall, Englewood Cliffs, N.J., 1958. 443 pp. $7.

Miscellaneous Publications

(Inquiries concerning these publications should be addressed, not to Science, *but to the publisher or agency sponsoring the publication.)*

Proceedings of the VIth Annual Meeting of the Japan EEG Society. Held in Sapporo 2–3 July 1957. Akashi Minoshima, Ed. Physiological Laboratory, Research Institute of Applied Electricity, Hokkaido University, Sapporo, Japan, 1957. 141 pp.

A Survey of Geology-Geophysics Students in the Colleges and Universities of the United States and Canada in 1956–57. Compiled by Bonnie C. Henderson. 1958. 9 pp. $0.50. *Earth for the Layman*. AGI Report 2. Mark W. Pangborn, Jr., ed. 2, 1957. 68 pp. $1. American Geological Institute, Washington 25.

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Final Report of the Advisory Committee on Weather Control. vols. 1 and 2. Howard T. Orville, Chairman. Supt. of Documents, GPO, Washington 25, 1958. 32 pp.; 422 pp.

The Attenuation of Gamma Rays and Neutrons in Reactor Shields. Herbert Goldstein. U.S. Atomic Energy Commission, Washington, 1957 (order from Supt. of Documents, GPO, Washington 25). 295 pp. $2.

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Reports

New Approach to Continuous Electrophoresis

Electrophoresis has long been a powerful tool in the laboratory for separating proteins, amino acids, colloids, and other complex mixtures of electrically charged particles. Though various types of apparatus are in use, the basic principle of operation is the same; individual components separate by virtue of differences in direction and rate of migration in electrical fields of up to several hundred volts. The recent trend toward continuous electrophoresis, as exemplified by the work of Durrum (*1*), Brattsten (*2*), and Bier (*3*), suggests that what was mainly an analytical method some 20 years ago may emerge as a preparative technique in its own right. Indeed, our whole concern was with the development of large-scale apparatus such as might be used to fractionate mixtures at the rate of liters per hour (*4*).

A central problem in electrophoresis is the remixing of partially separated fractions or layers by local density differences or thermal convection of the liquid as a whole. To cope with this problem, electrophoresis is often performed in anticonvection media such as filter paper, starch, or glass powder. Unfortunately, all such solids reduce capacity by their presence in the fractionation space, and they introduce such further complications as endosmosis, evaporation, adsorption, and "fanning" or "packing diffusion." In the hands of Brattsten and co-workers (*5*) these side effects have been minimized, but truly large-scale operation by their technique seems remote.

Stray convection currents can be especially detrimental in the Kirkwood-Cann method of electroconvection (*6*). Since the separation depends on convection transport by gravity in a liquid free of solid media, thermal effects must be minimized by close temperature control and operation at a density near the maximum density of water. In large apparatus the heat evolved by passage of electricity cannot be readily dissipated, and the problem is therefore intensified. A further drawback of electroconvection is that only one component at a time can be separated, and this criticism also applies to the continuous procedure of Bier (*3*).

We started from the premise that forced laminar flow was the most suitable way to suppress unwanted eddies. Furthermore, if the liquid flows upward, any slight decrease in its density by electrical heating as it passes through the potential field will tend to aid rather than oppose the motion. Thickening agents like Methocel or dextran permit mobilities practically equal to those in pure water and yet they act to suppress eddies.

Considerable preliminary work led to the design of an apparatus made of Lucite, incorporating some of these ideas (*7*). The principle of operation is shown in Fig. 1. Separation takes place in a 4-foot vertical column of rectangular cross-section (about 3 by 2 in.) filled with a viscous fluid in upward laminar motion (*S*). The mixture to be separated is injected at the bottom of the column through a centrally located duct with a slit opening (40 by 2 mm). This duct was designed to distribute the mixture over its entire area at the slit opening. Knife-edges ensure that there is minimum disturbance to the general pattern of viscous flow at the point of entry (*I*).

At the top of the column is a series of seven similar ducts (45 by 3 mm) centrally located and separated from one another by single knife-edges (*O*). These are oriented in the same direction as the feed duct and serve as flow splitters. The potential field is applied transverse to the direction of flow at electrodes located in special compartments (*E*) which are separated from the main column by rigid porous walls of a thermoplastic resin (*PW*). The potential field extends to a height of 40 in. Provisions are made for balancing pressures between electrode compartments and the main column.

When no potential is applied, the mixture proceeds up the center of the column as a single ribbon and leaves through the middle duct at the top of the column. However, when a potential is applied, the single band splits up into several individual bands corresponding to the number of separable components. Under favorable conditions these can be withdrawn through separate ducts at the top.

One set of typical results, shown at the right in Fig. 1, was obtained with a mixture of basic fuchsin, bromthymol blue, and bromphenol blue at a flow rate of about 5 ml/min. Photographs were taken at the top of the column, just beyond the potential field. The mixture split up into three distinct bands (from left to right, basic fuchsin, bromthymol blue, and bromphenol blue) which appeared red, yellow, and blue, respectively, on color photographs. Unfortu-

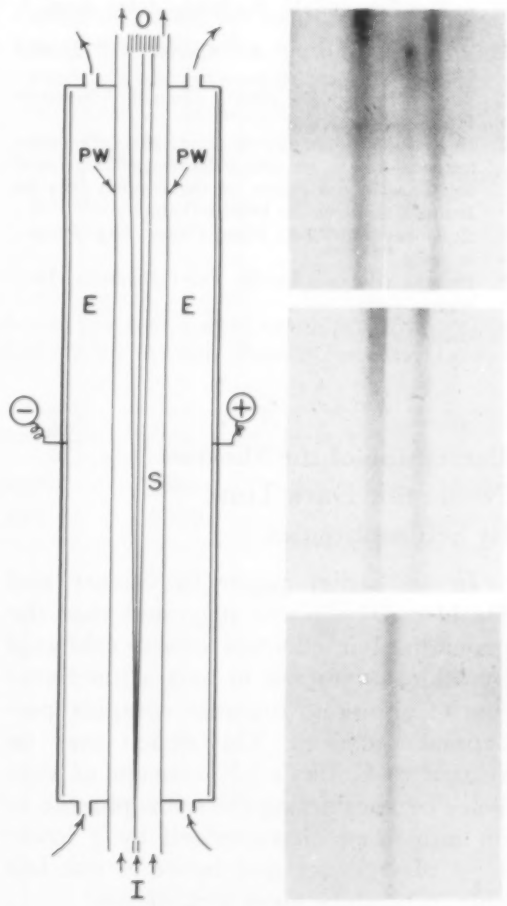

Fig. 1. (Left) Schematic diagram of apparatus. (Right) Typical results with a dye mixture of basic fuchsin, bromthymol blue, and bromphenol blue. The average linear rates of flow (*8*) and voltage drops, respectively, across the column were as follows: (bottom right) 3.4 mm/sec, 0 v/cm; (middle right) 3.4 mm/sec, 6 v/cm; (top right) 2.9 mm/sec, 6 v/cm. Other conditions were: temperature, 24°C; current density, 3.5×10^{-4} amp/cm^2; conductivity of solution (0.351 Methocel plus acetate buffer), 5.5×10^{-5} ohm^{-1} cm^{-1}; viscosity, 10 cp; *p*H, 5.3.

All technical papers are published in this section. Manuscripts should be typed double-spaced and be submitted in duplicate. In length, they should be limited to the equivalent of 1200 words; this includes the space occupied by illustrative or tabular material, references and notes, and the author(s)' name(s) and affiliation(s). Illustrative material should be limited to one table *or* one figure. All explanatory notes, including acknowledgments and authorization for publication, and literature references are to be numbered consecutively, keyed into the text proper, and placed at the end of the article under the heading "References and Notes." For fuller details see "Suggestions to Contributors" in *Science* 125, 16 (4 Jan. 1957).

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nately, the yellow color was almost entirely lost in the black-and-white reproduction. At the lowest rate of flow, distances between the centers of color bands were 7 mm, red to yellow, and 3 mm, yellow to blue, with colorless spaces in between. Thus it was possible to perform a complete separation with the knife-edged flow splitter at the top of the column.

It should be emphasized that these are preliminary results; no protein mixtures have been tested as yet. The technique seems sufficiently novel, however, to merit early reporting (*9*).

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8. In estimating retention time, due allowance must be made for the velocity profile. Local velocities in the center of the column may be as much as twice the average velocity.
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15 November 1957

Perception of the Shortest Noticeable Dark Time by Schizophrenics

In an earlier paper by Saucer and Deabler (*1*), it was suggested that the generalized intellectual deficit exhibited by schizophrenics is in part a functional loss of ability to organize complex perceptual processes. This deficit may be related to Koffka's (*2*) concept of vigilance by considering the schizophrenic as an individual characterized by a lower level of vigilance and hence as one less able to produce good articulation.

Concerning vigilance, Koffka has said: "When the organism is active, at a high state of vigilance to use Sir Henry Head's term, it will produce good articulation; when it is passive, in a state of low vigilance, it will produce uniformity" (*2*).

Articulation may be defined as (i) a sharp separation between figure and ground or (ii) the isolation and preservation of *Gestalten* in an ambiguous situation. Our concern here is largely with the first definition, since critical flicker fusion (CFF) is studied in terms of a rigidly organized figure-ground relationship, although it must be stated that the light phase may be either figure or ground.

Critical flicker fusion clearly provides the necessary poles of articulation as flicker and uniformity as fusion. Therefore, CFF techniques may be expected to show a lowered ability to produce good articulation in schizophrenia.

Such a relationship has not yet been clearly demonstrated. This may be in part due to the choice of stimulus parameters. Conventional CFF studies have for the most part been carried out by the use of the General Radio Strobotac which has a light-dark ratio of approximately 1:5000 at fusion or by the use of the Tachisticope with a 1:1 light-dark ratio. Tanner (*3*) reported a study in which the light time was held constant and fusion was obtained by shortening the dark interval between flashes. He found that, under these conditions, correlations as high as .513 at the 5 percent level of significance between the shortest noticeable dark time and American College Entrance test scores could be demonstrated. It is his suggestion that neither a short light-dark ratio nor a 1:1 light-dark ratio presents optimal stimulus conditions for the study of relationships between CFF and psychological variables.

It is hypothesized that if Tanner's technique is applied to the question of articulation by schizophrenics, then the expected significant relationship between schizophrenia and CFF may be shown to exist. This paper is the report of an experiment in which schizophrenic and control subjects are compared with respect to the shortest noticeable dark time, it being expected that the schizophrenics will have a significantly longer shortest noticeable dark time at fusion.

Stimulation was provided by a fluorescent neon bulb (Westinghouse Nitelite) arranged to shine through a ¾-in. aperture. A ⅛-in. opal Lucite filter was interposed between the light and the aperture to provide uniform and diffuse illumination. The length of the light flash was fixed at 50 msec (a compromise between the 38- and 84-msec periods used by Tanner), and the intensity adjusted until a pilot group of normal observers reported fusion at SND times approximately the same as the 6.44-msec time reported by Tanner.

The light was gated by an asymmetrical multivibrator (*4*). On and off times could be varied independently over a range of 0.4 to 400 msec. The light fraction and the dark fraction were measured by means of a Tektronix 360 cathode-ray synchroscope and 162 pulse generator.

Control subjects were seven psychologically naive hospital staff members, six nonpsychotic neuro[illegible]hiatric patients, and six nonneuro[illegible]hiatric patients from the medical [illegible]vice of the Perry Point (Md.) VA [illegible]spital. The experimental subjects were [illegible] acute and chronic schizophrenic pati[illegible]s from the neuropsychiatric wards of t[illegible] hospital.

Subjects were brought in[illegible] the laboratory and given a brief p[illegible]od of dark adaptation. For half the [illegible]ubjects, this period was 1 minute, for the other half, 3 minutes. After the dark-adaptation procedure was finished, it was demonstrated that the operator could vary the light from a clearly flickering state to a state of fusion.

The subjects were again shown the flickering phase and asked to report "when the light stops flickering." The shortest noticeable dark time was recorded, and the dark fraction was decreased well beyond this point. The subject was then asked to report "when the light starts to flicker." No further instructions were given. An ascending-descending series of six measures was taken.

There were no significant differences due to dark adaptation. The mean shortest noticeable dark time for the schizophrenic group was 11.58 msec with a standard deviation of 5.87 msec. The mean shortest noticeable dark time was 7.47 msec for the control group with a standard deviation of 0.833 msec. Although it is evident that there are gross differences in variance between the two groups (F ratio = 37.71 for 19 degrees of freedom), a t of 3.12, significant at the .002 level for a one-tailed test was computed.

Since the variances were obviously noncommensurate, nonparametric statistics were applied. For the rank order differences a Mann-Whitney CR of 3.72, significant at the .0001 level of confidence, was obtained. If the 19 high scores were taken as "normal" and the 20 low scores were taken as "schizophrenic," then 34/39 of the group could be correctly identified.

We feel that the null hypothesis of no true difference in shortest noticeable dark time between the control and schizophrenic group can be rejected at an adequate level of confidence.

Under these conditions of stimulus presentation, the schizophrenic is evidently less able to maintain good articulation. It is believed that the term *lowered vigilance* may be applicable to the schizophrenic. As a clinical concept, vigilance is useful in that it may serve to unify demonstrated relationships between CFF and a variety of psychological factors.

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16 September 1957

Leukemia in Hiroshima City Atomic Bomb Survivors

It has become generally accepted that an increased incidence of leukemia follows the acute or chronic exposure of various experimental animals and of man to ionizing radiation (*1*). Recently an attempt has been made to establish a quantitative relation beween the probability of radiation-induced leukemia and the unit-dose of radiation received, on the basis of data from studies of various groups of radiation-exposed human beings (*2*).

The survivors of the atomic bombings in Hiroshima and Nagasaki, Japan, comprise two such groups. Reports concerning the occurrence of leukemia in these populations over a period, through June 1956, have been published at intervals by various staff members (*3*) of the Atomic Bomb Casualty Commission (*4*). In addition, an unpublished compilation of certain specific detailed information requested by the British Medical Research Council was prepared in September 1955 (*5*). An analysis of these data appeared in a publication of the Medical Research Council (*6*), and a portion was also published in a report of the National Research Council (*7*).

Since that time a review has been made of all the leukemia cases known to the Atomic Bomb Casualty Commission, and a master list has been compiled. Some of the cases on the September 1955 listing have been dropped for various reasons, and many cases have been added. No detailed official report has been published recently, in the hope that more adequate dosimetry data might become available. This wish is nearing fulfillment because of the joint initiation of a large program of dosimetry studies in 1955 by the Atomic Bomb Casualty Commission and a group of interested organizations, including the Atomic Energy Commission's Division of Biology and Medicine, the National Academy of Sciences–National Research Council, the U.S. Air Force School of Aviation Medicine, Los Alamos Scientific Laboratory, and Oak Ridge National Laboratory. The program is designed to make possible the assignment of a specific neutron or gamma ray dose, or both, in rads to the record of each survivor in the Atomic Bomb Casualty Commission's files for whom sufficient pertinent information is available.

A detailed interim report on leukemia in the Hiroshima atomic bomb survivors is presently being prepared by various staff members of the Atomic Bomb Casualty Commission and the National Research Council. It will include the best currently available dosimetry information resulting from the afore-mentioned collaborative effort. However, because of the present interest in data pertinent to radiation leukemogenesis and the desirability of making available current information obtained by the Atomic Bomb Casualty Commission, Table 1, summarizing results of the leukemia survey in Hiroshima as of December 1957, is presented at this time.

Certain limitations of these data should be pointed out. The program was initiated in 1947, but the present level of intensity of effort was not achieved until about 1950. Therefore, while it may be assumed that the numbers of cases shown for the years 1950 through 1956 are fairly accurate, the numbers that arose in the preceding years may be understated rather seriously. With respect to 1957, it is probable that additional cases remain to be discovered with onset in that year.

The denominators of the incidence rates are estimates, subject to errors of presently unknown magnitude. The 3 June 1953 residential census of Hiroshima was conducted by the Hiroshima Census Bureau and was presumably of a reasonable degree of accuracy. The categorization by distance from the hypocenter was made on the basis of Atomic Bomb Casualty Commission investigations of 50.8 percent of the males and 44.6 percent of the females who reported themselves exposed to the bomb. However, it was found that 3.1 percent of those reportedly exposed were in fact not in the city at the exact time of the bombing.

Apart from the uncertainties regarding the population on 3 June 1953, it may be incorrect to assume that migration in and out of the city during the period from 1950 to the present was the same for persons exposed in different distance categories. However, despite the current lack of pertinent information, the simple expedient of multiplying the June 1953 population values by eight to obtain estimates of person-years at risk has been adopted, since the census date is roughly near the mid-point of the interval under study. This procedure seems reasonable at present, although the magnitude of any resultant error is hard to estimate.

In addition to the above-mentioned points, which have to do with the in-

Table 1. Leukemia in Hiroshima atomic bomb survivors who were residents of Hiroshima City at the time of diagnosis (diagnoses verified by the Atomic Bomb Casualty Commission), as of December 1957.

Year of onset	Total	Distance from hypocenter (meters)				
		Under 1000	1000–1499	1500–1999	2000–2999	3000 and over
1945						
1946						
1947	3		1		2	
1948	7	2	4		1	
1949	5	1	1	1	1	1
1950	9	3	5			1
1951	11	3	7	1		
1952	11	3	5	1		2
1953	12	2	6	2	1	1
1954	6	2	2	1	1	
1955	8	1	4	2		1
1956	6		1	1	1	3
1957	5	1	3			1
Total	83	18	39	9	7	10
		*Estimated population**				
	95,819	1,241	8,810	20,113	32,692	32,963
		Number of cases with onset in 1950–1957				
	68	15	33	8	3	9
		Estimated person–years at risk				
	766,552	9,928	70,480	160,904	261,536	263,704
		Annual incidence of leukemia per 100,000				
	8.9	151.1	46.8	5.0	1.1	3.4

* Based on Hiroshima Census Bureau's daytime population census of Hiroshima City, 3 June 1953.

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trinsic accuracy of the data presented, a further caution should be strongly emphasized. The uncertainties involved in inferring radiation dose from distance alone are too large to support conclusions beyond the previously reported qualitative one that those survivors who received large doses of radiation—that is, who were within 1500 meters of the hypocenter—had a significantly higher incidence of leukemia than those beyond that distance, who received relatively little or none (*3*). The relationship of incidence to distance as presented in Table 1 cannot be given a more quantitative interpretation because there are too many variables, as yet unresolved, which cannot be ignored.

For example, the presently available estimates of the air dose in Hiroshima have a large uncertainty, the magnitude of which is itself not yet definite. Also, experimental dosimetry studies at Oak Ridge National Laboratory emphasize the need for detailed information, such as is being collected by the Atomic Bomb Casualty Commission, concerning the shielding situation of any particular survivor at any distance. It is conceivable that the radiation received within a light frame house (the most common shielding situation) may vary from an amount almost equaling the outside air dose to one equal to the outside air dose attenuated by perhaps a factor of two, depending on the position of the person in the house.

In determining the relationship of radiation exposure to the incidence of leukemia, such detailed data must be examined not only for each leukemic survivor but also for enough of the population at risk to permit calculation of statistically significant incidence rates. Until this information becomes available from the dosimetry program, it is premature to attempt precise quantitation of dose-effect relationships in radiation leukemogenesis on the basis of the Hiroshima and Nagasaki radiation-exposed populations (*8*).

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20 December 1957

Stimulating Action of Soluble Antigen-Antibody Complexes on Normal Guinea-Pig Smooth Muscle

During the course of a study on the disappearance of soluble antigen-antibody complexes in rabbits, it was observed that normal rabbits exhibited moderate-to-severe shock following the intravenous injection of solutions containing soluble antigen-antibody complexes prepared by dissolving precipitates in excess antigen. The significance of these observations was not fully appreciated until Germuth and McKinnon (*1*) reported their work on the production of shock in guinea pigs following the injection of soluble antigen-antibody complexes formed in excess antigen.

In view of these findings, the investigation described in this report (*2*) was made to determine the effect of such soluble complexes on isolated strips of smooth muscle from the intestine of normal guinea pigs. The Schultz-Dale technique of in vitro tissue anaphylaxis provides a more sensitive measure of the irritability of soluble antigen-antibody complexes than other techniques, and it was thought that this technique might indicate whether nontoxic soluble complexes could be obtained that would permit continuation of the in vivo studies on the disappearance and fate of soluble complexes in rabbits.

The antigen used in this study was recrystallized bovine serum albumin (BSA) (*3*). A pool of antiserum was obtained from rabbits following 12 intravenous injections (of 10 mg each) given over a period of about 4 weeks. Quantitative precipitin curves were obtained by the method described by Lanni and Campbell (*4*). Each tube contained 3 ml of the antigen dilution and 3 ml of undiluted antiserum. The diluent used was saline-borate buffer [illegible] 8.4; μ = 0.006 borate and $\mu = 0.16$ [illegible] Cl). After the tubes had been kept [illegible] hours at 4°C, they were centrifuged [illegible] 45 minutes at 3000 rev/min (160[illegible] g) in a refrigerated centrifuge, and [illegible] clear supernates were decanted into a separate set of tubes. The precipitates were washed and then analyzed for total nitrogen by Nesslerization (*4*). The guinea pigs used for this work were normal nonsensitized animals, each weighing between 400–500 g. Each animal was killed by a blow on the head, and 30 to 40 cm of the lower portion of the small intestine was carefully removed and kept moistened at all times with warm modified Tyrode solution (*5*). The intestinal contents were carefully removed by flushing the intestine with three or four 25-ml portions of fresh Tyrode solution.

Each supernate was tested, by the method of Campbell and McCasland (*6*), on fresh duplicate strips of guinea-pig ileum (3 to 4 cm in length) from two different animals. The strips were immersed in a 120-ml muscle bath containing Tyrode solution at 37°C, and a stream of O_2 (90 percent) plus CO_2 (10 percent) was used to aerate and stir the bath. The experimental procedure was to allow the muscle strips to equilibrate in the bath for 15 minutes, add 2 ml of the supernate to be tested, and record the subsequent contraction of the muscle strip for a 10-minute period. Five micrograms of histamine was then added to the bath as a means of obtaining a value for maximal contraction. The stimulating effect of soluble complex was expressed as a percentage of the maximal contraction obtained with histamine.

Control tests were made with solutions containing only antiserum or normal rabbit serums, varying in amounts from 0.08 to 3.64 times the amount of protein in

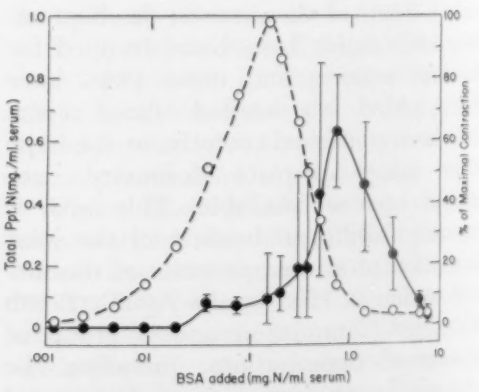

Fig. 1. Relationship between the precipitin curve (open circles) and smooth-muscle contraction (closed circles). The contraction of the guinea-pig ileum is expressed as a percentage of the maximal response obtained with histamine and is the average for six intestinal strips. The range is indicated by the vertical lines.

Table 1. Effect of BSA–anti-BSA supernates on smooth muscle of guinea pig.

Antigen N added per milliliter of serum (mg)	Total ppt of N (mg per ml of serum)	Tests on supernates: Excess antigen or antibody	Schultz-Dale (% of max.)*	Skin reaction
7.3465	0.037	Antigen	3	++
5.8772	0.037	Antigen	8	+
2.9386	0.048	Antigen	23	++
1.4693	0.048	Antigen	46	+++
0.7347	0.135	Antigen	63	+++
0.4898	0.346	Antigen	43	+++
0.3673	0.500	Antigen	19	+++
0.2939	0.663	Antigen	19	+
0.1959	0.867	Antigen	11	±
0.1469	0.982	Antigen	9	±
0.0735	0.750	Antibody	7	+
0.0368	0.515	Antibody	8	++
0.0184	0.263	Antibody	0	+
0.0092	0.140	Antibody	0	+
0.0046	0.067	Antibody	0	+
0.0023	0.037	Antibody	0	+
0.0012	0.020	Antibody	0	+
Antiserum control	0.00	Antibody	0	−
Histamine (1.0 μg)			100	++++
1% NaCl				−

* Based on the reaction to 5 μg of histamine as 100 percent. The values shown are the average for six strips of ileum.

the supernatant solutions. Control tests were also made on bovine serum albumin solutions alone and on mixtures of bovine serum albumin and normal serum. In no instance did these control systems cause any smooth-muscle contraction. The supernates were also tested for their skin reactivity by intradermal injection into the skin of normal guinea pigs which had previously received an intravenous injection of Evans blue (Table 1).

The data (Fig. 1) showed that the principal activity of the supernates occurred in the range of slight-to-moderate antigen excess. The stimulating action rapidly decreased to zero in antibody excess and nearly so in extreme antigen excess. It was noted that there was a time lag of from 30 to 90 seconds between the addition of the test solution and the contraction of the muscle. This lag was much greater than that ordinarily seen with histamine or when antigen is added to sensitized tissue, and this suggests that a different mechanism may be involved. All tissues which were allowed to react to an initial exposure of supernate, and which were then washed and exposed again, failed to contract; this is suggestive of an immune reaction. This of course is similar to typical desensitization of muscle from a sensitized animal in that the muscle becomes refractory to antigen after the primary exposure. Further studies must be made before the real significance of soluble antigen-antibody complexes in hypersensitivity reactions is understood. For example, the problem arises whether soluble complexes in excess antibody (that is, toxin-antitoxin systems) would give reactions, and whether the failure to obtain reactions in cases of extreme antigen excess is due to an inhibitory effect of free antigen or to the nature of the complexes (see Singer and Campbell, 7). The same reaction can be obtained with soluble complexes formed by dissolving carefully washed precipitates in excess antigen. However, no study has been made of solubilized precipitates formed in a decomplemented serum.

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20 November 1957

N-Terminal Amino Acid and Lipid Composition of Lipoproteins from Chyle and Plasma

One of the major theories of fat transport is that lipoproteins rich in triglycerides (S_f 20–400 and chylomicrons) are transformed into higher density lipoproteins by the successive removal of triglycerides (*1*). Two primary problems arising from this hypothesis are the relationships between two of the major classes of lipoproteins found in human plasma [*D*, 1.006–1.063 (S_f 0–20) and *D*, 1.063–1.21 (HDL)] to each other and to the lipoproteins of density less than 1.006 which appear to be the principal vehicles for triglyceride transport. If any classes of lipoproteins are interconvertible then they must contain identical protein moieties and differ only by reason of their lipid constituents. The amino acid end group analyses of Avigan *et al.* (*2*) and Shore (*3*) and studies utilizing labeled lipoproteins have demonstrated conclusively that the predominant components of two classes, *D*, 1.019–1.063 and *D*, 1.063–1.21 are not interconvertible. These results exclude the possibility that all of the lipoproteins of human plasma represent a continuous spectrum containing a common protein. However, the relationship of these lipoproteins to those having densities less than 1.006 (chylomicrons and S_f 20–400) has not been reported.

This paper contains the results of N-terminal amino acid analyses of the protein moieties of the complete spectrum of lipoproteins from the chylomicrons of chyle to the highest density lipoproteins (*D*, 1.063–1.21) in plasma.

Chylomicrons from chyle were obtained from a patient with a chylothorax associated with Hodgkins disease. Fractions I, II, and III (Fig. 1) were obtained from three separate patients with idiopathic hyperlipemia. Fractions IV, V, VI, and VII were obtained from the plasma of blood bank donors at the National Institutes of Health.

Chylomicrons from chyle and plasma (fraction I) were isolated by layering the chyle or plasma under saline at density 1.006 and centrifuging at 50,000 *g* for 30 minutes in the Spinco 21 rotor. The packed chylomicrons were then suspended in 30 percent sucrose and layered under 10 volumes of 0.055*M* phosphate, *p*H 7.0, and recentrifuged at 50,000 *g* for 30 minutes. This process was repeated up to eight times until a constant protein concentration was obtained. After removal of the chylomicrons, the plasma was centrifuged at density 1.006 for 24 hours at 80,000 to 90,000 *g*. The packed yellow material (fraction II) at the top of the tube was suspended in 30 percent sucrose and layered under 0.055*M* phos-

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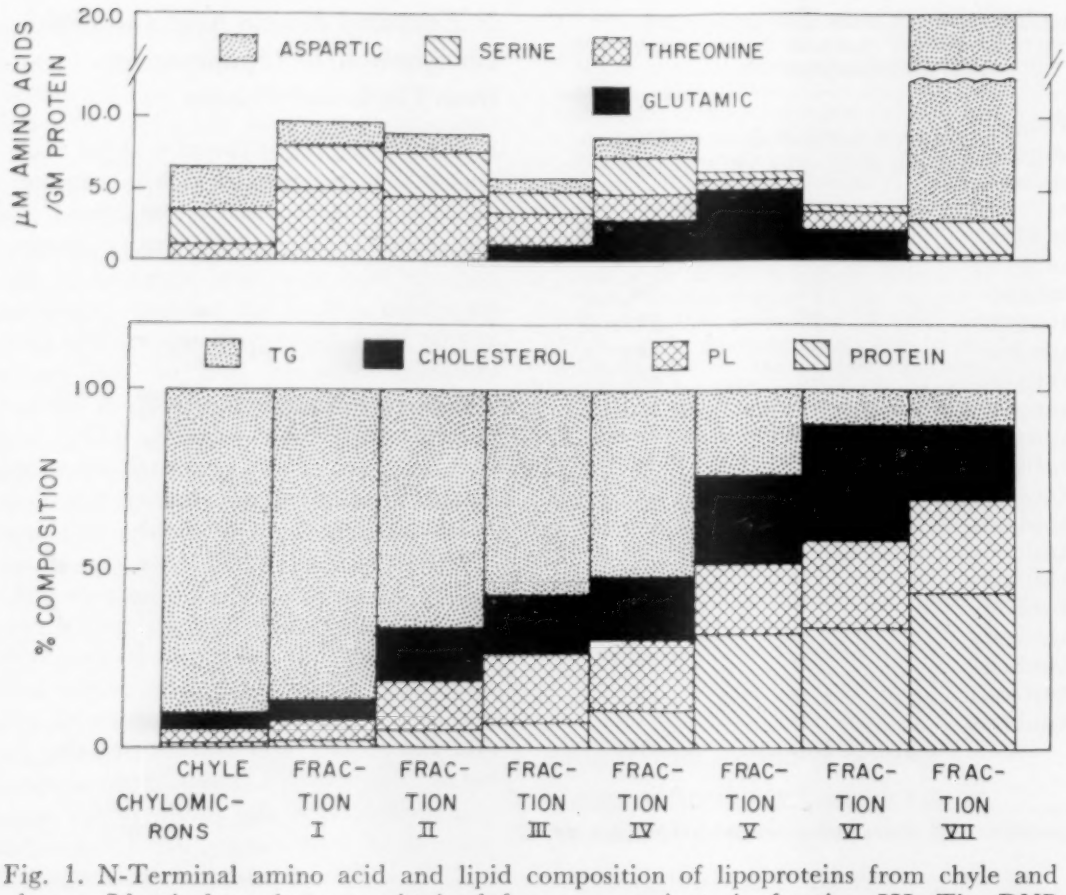

Fig. 1. N-Terminal amino acid and lipid composition of lipoproteins from chyle and plasma. Identical results were obtained from two patients in fraction III. The DNP aspartic acid recovery in fraction VII indicated a minimum molecular weight of 54,000. For dog plasma the same fraction contained only N-terminal aspartic acid with a recovery indicating a minimum molecular weight of 46,000 (*13*).

phate, *p*H 7.0, and recentrifuged. This process was repeated until constant protein concentration was achieved. After removal of fraction II, the soluble lipoproteins which floated were further washed to obtain fractions III and IV. The techniques of isolation of fractions V, VI and VII were essentially those described by Havel *et al.* (*4*) and represent lipoproteins that floated at densities 1.019, 1.063, and 1.21, respectively.

The lipid and protein content of each fraction was obtained according to the procedures used by Bragdon *et al.* (*5*) and was utilized in conjunction with data published by Oncley *et al.* (*6*) to approximate the range of S_f classes represented by each fraction. Fraction III corresponds roughly to S_f 40–100, fraction IV to S_f 20–50, fraction V to S_f 10–17, fraction VI to S_f 3–8, and fraction VII to the high density classes described by Gofman *et al.* (*7*).

The lipoproteins were freed of lipid by extraction with chloroform–methanol (2:1) and further extracted with alcohol, alcohol–acetone, and ether. The protein was reacted with dinitrofluorobenzene and then hydrolyzed. The DNP amino acids were chromatographed and measured quantitatively according to the procedure of Levy (*8*). The chromatographic procedure of Blackburn and Lowther (*9*) was used for final identification of the DNP amino acids. The correction factors used for losses during hydrolysis were those of Porter (*10*).

The results presented in Fig. 1 indicate that while N-terminal threonine and serine appear in all the fractions, they are the predominant N-terminal amino acids in fractions I to IV, the major carriers of triglyceride in plasma. N-Terminal aspartic acid appears in these fractions as well as in fraction VII, although the presence of N-terminal aspartic acid in all of these fractions, of course, does not necessarily mean that the proteins containing the aspartic acid are identical (*11*). N-Terminal glutamic acid, however, appears to be present only in fractions III to VI. It therefore is extremely unlikely that the chyle and plasma chylomicrons and the bulk of the other lipoproteins of density less than 1.006 are "convertible" to the major lipoprotein of *D* 1.006–1.063. Furthermore, the results indicate that the very low density lipoproteins, whose primary distinguishing feature is the high percentage of triglyceride, represent a group of proteins with N-terminal serine, threonine, and aspartic acid.

Since the proteins containing N-terminal serine, threonine, and aspartic acid do not appear to have any stoichiometric relationship to one another, it must be concluded that these proteins are not part of a molecular unit but are distinct entities. Obviously no functional role can be assigned to any one of these proteins until they are isolated and studied separately although it would appear that one or more of them must be intimately associated with the transport of triglyceride.

Any concept concerning lipid transport in plasma must be based on a study of the metabolism of the individual proteins as well as the lipid moieties, since each protein may have a specific role in the metabolism of lipids. It is also apparent that the methods presently used for the isolation of plasma lipoproteins are not adequate for isolating homogeneous lipoproteins. New methods for their purification are now being developed in this laboratory to facilitate further studies of the metabolic and structural properties of plasma lipoproteins (*12*).

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12. I express my appreciation to Dr. Donald S. Fredrickson for the procurement of the patients utilized in this study and to Dr. Edward Korn for his interest and stimulation in all phases of this work.
13. M. Rodbell, unpublished results.

18 November 1957

Yellow Acid-Cation Complexes in Lake Water

Recent studies of the yellow materials present in natural waters and commonly called humins or tannins (*1*) have shown that these materials consist of ultraviolet fluorescing dicarboxylic hydroxy aliphatic organic acids of molecular weight approximately 450. They are probably unsaturated and are apparently non-nitrogenous, containing only carbon, hydrogen, and oxygen. These acids are present in

quantities that, for lakes, are remarkably large (at least 5 mg/lit in Linsley Pond, a small, but not highly colored, lake in Connecticut) and, aside from their coloring role and consequent effects on light absorption, are important in that they stimulate the growth of certain limnetic algae. In addition, they may be important chelating agents and, in fact, are capable of keeping iron in a nonprecipitable state at a *p*H as high as 9.5 for at least several weeks.

The problem of determining the number of yellow substances involved is not an easy one. For example, in Fig. 1, *A* is a photograph, made by ultraviolet light, of a paper chromatogram of an 80 percent ethanol extract of dried residue from the water of Zoar Lake, Connecticut; it shows results typical of those obtained from Connecticut lakes. (The solvent consisted of water, tertiary amyl alcohol, pyridine, and diethylamine, (25:25:25:1). The paper was Whatman No. 3.) Figure 1 *B* is a similarly run chromatogram of material from Panther Lake, Washington; it also shows regionally typical results. The two patterns consist of several zones and are very similar even though the lakes are separated by a distance of about 3000 miles.

Several possible explanations are apparent: (i) The chromatographic zones may represent a series of different acids, all of which are common to all of the lakes examined; (ii) the zones may represent dimers, trimers, or polymers of a small number (possibly one) of acids; (iii) the zones may represent different salts or complexes of one or more acids. On the basis of infrared spectra of eluted zones, and perhaps even on the basis of probability, the first possibility seems to be unlikely. The second may be true, especially in the light of the free hydroxyl groups, but is difficult to test. The third, or salt hypothesis, can be checked.

To test this hypothesis, advantage was taken of the fact that the materials, being acidic, are extractable from acidified lake water concentrates with ethyl acetate. Paper chromatograms of such extracts show two rather blurred zones of high R_f but otherwise have little detail (Fig. 1 *C*). However, if the preparation is mixed, before chromatography, with a solution of the salts of Ca, Mg, Na, K, and Fe, the story is quite different (Fig. 1 *D*). The two fast-running areas are present as before, but now the similarity to *A* and *B* is striking. Here, then, is a possible explanation for the chromatographic similarity of lakes, since the ions used are uniformly present.

Further experiments with single salts show that, while the iron apparently has no effect, the zone at the origin (extreme right in Fig. 1) is associated with magnesium and appears only in its presence. [On a previous occasion (*1*), Ca alone yielded a weak zone at the origin. This result is now believed to have been due to contamination with a magnesium salt.] The next zone (R_f about 0.10) appears only with Na, K, or Rb and not with Li. Flame photometric analyses of individually eluted zones yielded the same conclusion.

An interesting adjunct to these observations has come from a study of two lakes each of which lacked one of the characteristic chromatographic zones. One of these is a small pond near Olalla, British Columbia; a chromatogram of its waters is shown in Fig. 1 *E*. The zone at the origin is absent. When $MgCl_2$ (but not $CaCl_2$) is added to the ethanol extract before running, the zone appears (Fig. 1 *F*). The second lake, Hot Lake, is in Washington, and in this case the zone at the origin is strong but the second zone is vague or absent (Fig. 1, *G*). Addition to the ethanol extract before chromatography, of either NaCl or KCl restores this zone (Fig. 1 *H*). Thus, the earlier results linking certain zones with specific ions are confirmed.

It might therefore be expected that Olalla Pond would be deficient in Mg and Hot Lake low in Na and K. However, Olalla Pond contains, in addition to 30 mg of Na per liter, 7 mg of Mg per liter; and Hot Lake, which occupies the excavation of an old epsom salt mine and, in consequence, has about 14,000 mg of Mg per liter, also has 4500 mg of Na per liter and 640 mg of K per liter. This might suggest that the Na/Mg ratio is important in determining the chromatographic pattern, since Olalla Pond has a ratio of 4.3 compared to 0.32 for Hot Lake; but in spite of the encouraging fact that the two other Washington lakes that lack the "magnesium" zone —Soap Lake and Blue Lake—had ratios of 680 and 3.5 respectively, two more lakes had ratios of 5 and 10, respectively, and each had a strong zone at the origin. Thus, it was necessary to find another explanation.

With regard to the three lakes that lack the zone at the origin, the only unique factor was their high *p*H, which was above 8.4 in each case. (The *p*H of all of the other lakes studied was between 6.9 and 8.2.) That these three lakes still contained appreciable amounts of magnesium precluded the possibility that the absence of the "magnesium zone" was due to the precipitation of the metal as the hydroxide. Rather, it is more likely that the magnesium "salt" either does not form or that it dissociates at the higher *p*H, or that it becomes destroyed during evaporation, even though evaporation is carried out under vacuum.

To check on these possibilities, water from Vaseaux Lake, British Columbia, (*p*H 8.2, zone at origin present) was raised to *p*H 9.7 with Na_2CO_3 and, after filtering, was evaporated in the usual way and separated by chromatography. The zone at the origin was absent. A similar sample was acidified with HCl after it had been applied to the starting line on the paper. In this case the zone appeared, although it was reduced in intensity.

Similarly, a sample of water from Olalla Pond (*p*H 8.4, zone at origin absent), acidified just before running, showed a weak zone. Furthermore it was shown that the presence or absence of the zone is not due to its being reversibly decolorized and recolorized by alkali and acid, respectively. The second zone was in no way affected by these procedures. Thus, it seems as though the formation of the magnesium "salt" is favored by a low *p*H, or, as in the case of the addition

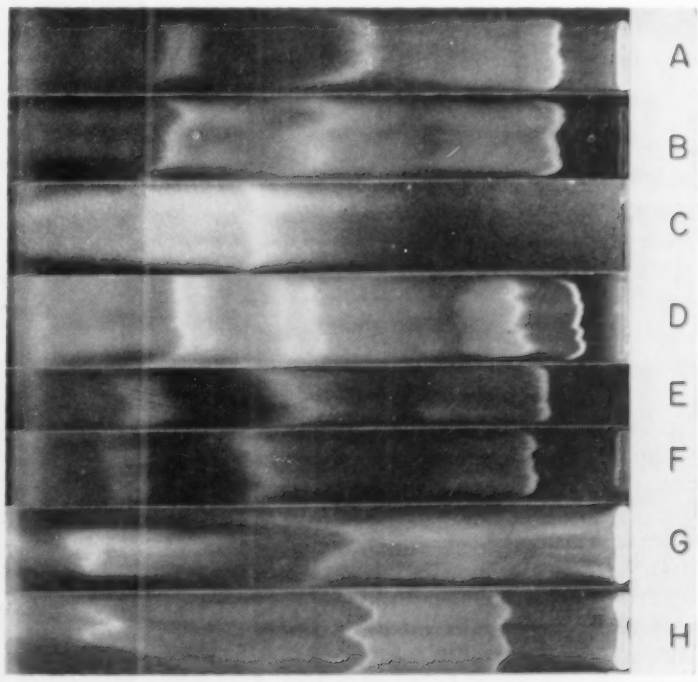

Fig. 1. Paper chromatograms of treated and untreated samples of lake water. Direction of solvent flow was from right to left. The appearance of the chromatograms results from their being photographed by ultraviolet light (see text for explanation of individual zones).

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of $MgCl_2$ to water from Olalla Pond, by a high concentration of Mg. The reduction, as in Hot Lake, of the second zone or sodium "salt" in the presence of a very high concentration of magnesium is possibly due to competition for attachment sites by the ions.

Lakes, then, have a reasonably uniform complement of organic "salts" or perhaps "complexes," the uniformity resting largely on the inorganic ions common to all. High *p*H values or a very high concentration of a single ion may modify the pattern. That the yellow acids are intimately associated with the ionic metabolism of lakes is clear. In addition to the connection of these acids with the major ions, preliminary studies have shown possible involvement with such less abundant, but biologically important, ions as cobalt, iron, manganese, copper, and zinc.

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8 November 1957

Effect of Iproniazid on Brain Levels of Norepinephrine and Serotonin

Iproniazid (1-isonicotinyl-2-isopropylhydrazine; Marsilid) was originally introduced as a drug for the treatment of tuberculosis, but was soon found to induce signs of central stimulation. Recent observations (*1*) indicate that the action on the central nervous system may be of value in treatment of depressed mental conditions.

Zeller *et al.* (*2*) were the first to observe that iproniazid inhibits monoamine oxidase, an enzyme which can inactivate norepinephrine and serotonin, substances which may be involved in central regulatory mechanisms (*3*). In a recent paper (*4*) we have presented evidence that monoamine oxidase has a major role in the physiologic inactivation of both monoamines in the brain. The data presented in this report show that repeated doses of iproniazid induce a marked rise in the brain levels of both norepinephrine and serotonin, together with signs of central stimulation.

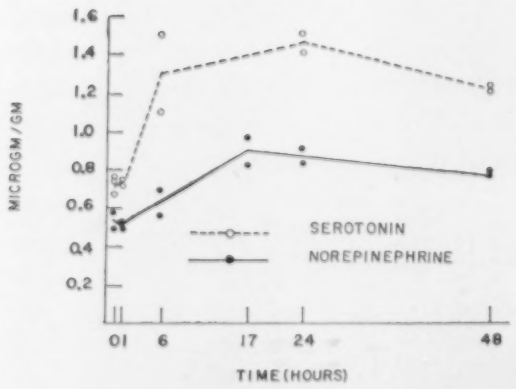

Fig. 1. Effect of a single large dose of iproniazid on serotonin and norepinephrine concentration in rabbit brain stem. Iproniazid (100 mg/kg) was injected subcutaneously. At various times thereafter animals were killed by intravenous injection of air, and the brain stems were analyzed. Each point represents the value from a single animal.

Iproniazid (100 mg/kg) was administered subcutaneously to rabbits, and the concentrations of norepinephrine and serotonin in the brain stem were measured at various times by previously described methods (*5, 6*). As is also reported by other workers (*7, 8*), the serotonin level increased markedly within a few hours after the administration of iproniazid. Norepinephrine levels also increased, but not as rapidly as those of serotonin (Fig. 1). No obvious pharmacological signs were evident.

Iproniazid was given daily in doses of 25 mg/kg subcutaneously to another group of rabbits. Serotonin and norepinephrine levels in the brain stem rose slowly, reaching about twice the normal value in 2 or 3 days (Fig. 2). By the third or fourth day a variable degree of central excitation was evident. Experiments in which the daily dose of iproniazid was 50 mg/kg elicited marked excitement in the animals on about the third day, when serotonin and norepinephrine levels had again risen about twofold. With a smaller daily dose of iproniazid (10 mg/kg), excitation was observed after 4 or 5 days, at which time

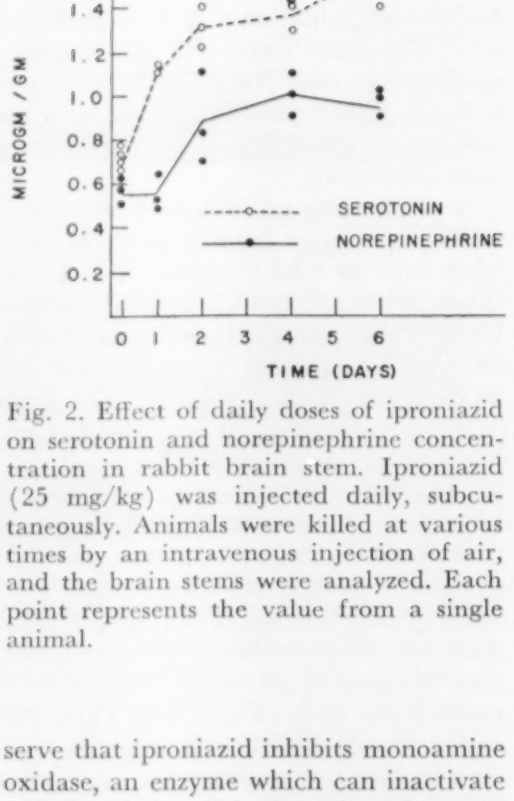

Fig. 2. Effect of daily doses of iproniazid on serotonin and norepinephrine concentration in rabbit brain stem. Iproniazid (25 mg/kg) was injected daily, subcutaneously. Animals were killed at various times by an intravenous injection of air, and the brain stems were analyzed. Each point represents the value from a single animal.

the brain levels of both amines were again about twice the normal values.

Isoniazid (isonicotinyl hydrazine), a congener of iproniazid, is a poor inhibitor of amine oxidase. In daily doses of 50 mg/kg it caused neither a rise in the brain concentration of the amines nor any obvious pharmacologic effect. On the other hand, α-methyl, β phenylethylhydrazine (JB 516, Lakeside Laboratories) a potent monoamine oxidase inhibitor of a different chemical series, when given daily in doses of 1 mg/kg, induced in 3 to 5 days pharmacologic effects similar to those seen after administration of iproniazid and raised the brain level of the amines about twofold.

It is not possible to conclude from the data given in this report that the central stimulatory effects of iproniazid are causally related to the increase in brain amines. It is noteworthy, however, that the administration of large doses of 3,4-dihydroxyphenylalanine (*9*), a norepinephrine precursor, or of 5-hydroxytryptophan (*7*), a serotonin precursor, causes central excitation which is enhanced by pretreatment with iproniazid.

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19 September 1957

Inhibition of Adrenocortical Steroid Secretion by Δ^4-Cholestenone

In the course of studies on Δ^4-cholestenone as an inhibitor of cholesterol biosynthesis it was noted that rats fed high doses of the compound developed striking (six- to eight-fold) hypertrophy of the adrenal glands (*1*). The effectiveness of Δ^4-cholestenone in depressing cholesterol synthesis (*1, 2*) and the demonstrated role of cholesterol as an intermediate in adrenal steroid synthesis (*3*) suggested that the latter might also be depressed. By direct measurement of cor-

Table 1. Effect of cholestenone on secretion of corticosterone by the rat adrenal. Group B was fed 1 percent cholestenone and group A the control ration.

Animal	Body weight (g)	Adrenal weight (mg)	Adrenal vein flow (plasma) (ml/min)	Corticosterone		
				µg%	µg/min	µg/mg of gland/min
			Group A			
1	235	11.0	0.041	878	0.36	0.033
2	273	13.8	0.179	762	1.36	0.099
3	262	13.0	0.050	1560	0.78	0.060
4	225	9.0	0.053	1042	0.55	0.061
Mean	249	11.7	0.081	1061	0.76	0.063
			Group B			
B-1	212	86.0	0.094	129	0.12	0.0014
B-2	230	83.0	0.061	152	0.09	0.0011
B-3	270	39.0	0.056	300	0.17	0.0044
B-4	212	103.0	0.032	223	0.07	0.0007
Mean	231	77.8	0.061	201	0.11	0.0019

ticoids in adrenal vein blood, it has now been found that the feeding of cholestenone results in a profound reduction of steroid output by the rat adrenal.

Male Sprague-Dawley rats were placed on a synthetic, cholesterol-free diet to which was added 1 percent cholestenone by weight (group B, Table 1). Rats in a control group (A) were pair-fed with the drug-fed rats; they maintained comparable weights. After 43 days, the animals in both groups were anesthetized with ether and Nembutal and heparinized, and left-adrenal vein blood was collected. The plasma content of corticosterone was determined by a spectrofluorometric method (*4*). The results shown in Table 1 indicate that the greatly enlarged glands of the treated animals were secreting corticosterone at a rate per unit weight of gland which was only about 3 percent of that in the controls.

Corticosterone and aldosterone were also determined specifically in pooled plasma samples from the adrenal vein collections by an isotope derivative technique (*5*). The values for corticosterone (in micrograms percent) obtained from the pooled plasmas by this method were: group A 1–2, 720; and group A 3–4, 742. The values in the treated animals were group B 1–2, 109; and group B 3–4, 192. These results were consistent with those obtained by the less specific method, which may be expected to yield somewhat higher values.

The values for aldosterone obtained on the same pooled samples were 5.6 and 6.1 µg percent in the control pairs, and 4.2 and 3.5 in the treated pairs. These data suggest that aldosterone secretion is likewise decreased.

Adrenal vein blood was also obtained from rats fed 1 percent cholestenone for only 12 days. The treated and control groups each contained 5 rats. The mean adrenal weights per unit body weight of the treated animals were 1.7 times those in the controls. In the treated rats the mean plasma corticosterone concentration was 57 percent and the output (per gram of gland per minute) 22 percent of that in the controls. These data indicate that inhibition of steroid output and adrenal hypertrophy both progress with continued feeding of cholestenone.

The general architecture of the hypertrophied adrenal glands from cholestenone-fed animals remains undisturbed, and the hypertrophy is limited to the cortex. The hypertrophied glands show very low concentrations of ascorbic acid and of cholesterol (*6*). On the other hand, the relative sterol content is either unchanged or slightly elevated, and the properties of this nonsaponifiable material suggest that it is largely dihydrocholesterol, known to be a major end-product of cholestenone metabolism (*7*).

There are several ways in which cholestenone feeding may be leading to inhibition of adrenal cortical function. (i) Cholesterol, known to be at least a potential precursor of many adrenal steroids (*3*), may be actually an obligatory precursor. An inhibition of adrenal cholesterol biosynthesis would then be reflected in an inhibition of steroid synthesis. (ii) The marked depression of serum and of adrenal cholesterol concentrations, due in part to replacement by dihydrocholesterol, may deprive the adrenal of cholesterol normally transported to it via the blood, and of its normal reserves of stored cholesterol, for use in steroid synthesis. (iii) Cholestenone, or its product dihydrocholesterol, may inhibit a reaction or reactions in the pathway of steroid synthesis from small precursors, even though that pathway does not necessarily involve cholesterol as an intermediate. The fact that simultaneous feeding of cholesterol partially protects rats against the toxic effects of cholestenone and limits the adrenal changes suggests that one of the first two mechanisms is of importance. These results emphasize the importance of considering the effect upon adrenal function of agents designed to lower plasma cholesterol, particularly through an inhibition of cholesterol synthesis.

The effects of Δ^4-cholestenone upon adrenocortical hormone secretion are being studied in other species and with regard to site of action. The toxicity of cholestenone (*6*) suggests that it will have little clinical application for the production of adrenocortical inhibition. However, these results offer another approach not only to the study of adrenocortical inhibitors but to that of the more basic mechanisms of hormone synthesis.

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16 January 1958

Respiratory Properties of the Hemoglobin of Two Species of Diving Birds

Comparison of the oxygen-hemoglobin equilibrium of three species of diving mammals (*1*) with terrestrial mammals indicates no significant differences. It would be of interest to know whether the respiratory properties of the hemoglobin of diving birds are essentially identical to those of nondiving forms (*2*).

Blood was obtained from the heart of freshly killed *Oidemia deglandi* (white-winged surf duck) and *Aechmophorus occidentalis* (western grebe). Erythrocytes were washed in an isotonic phosphate buffered Ringer's solution and either used immediately for determination of the oxygen equilibrium of erythrocyte suspensions or washed two more

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times and then hemolyzed in distilled water (5 volumes of water to 1 of packed red blood cells). Oxygen dissociation curves were determined spectrophotometrically (*3*). The data consist of percentage of oxyhemoglobin, y, as a function of partial pressure of oxygen, p. An approximately linear relationship is attained if log $[y/(100-y)]$ is plotted against log p. The two constants of the Hill equation are obtained from such a linear transformation: n, a measure of the heme-heme interaction, is the slope; p_{50}, a measure of the oxygen affinity, is that value of p at which log $[y/(100-y)]=0$. These two constants have been plotted as functions of pH in Fig. 1; each pair of values of n and p_{50} was obtained from an original oxygen dissociation curve based on six to eight determinations.

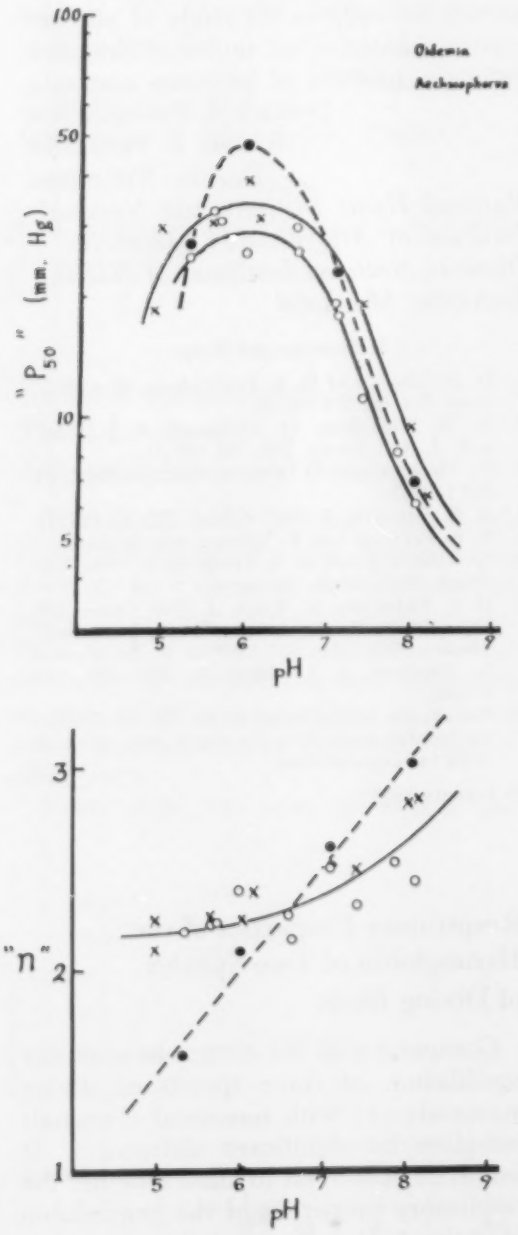

Fig. 1. Oxygen affinity and heme-heme interaction as functions of pH for the hemoglobin of two species of diving birds. Solid line, *Aechmophorus occidentalis* (western grebe); broken line, *Oidemia deglandi* (white-winged surf duck). Circles, 3 percent hemoglobin solution in potassium phosphate buffers; $\Gamma/2$ 0.267. Crosses, erythrocyte suspensions in isotonic sodium phosphate buffered Ringer's solution. Temperature, 24 to 26°C.

Certain biochemical and physiological conclusions can be drawn from the information given in Fig. 1, which includes the first published complete comparison of the Bohr effect of a hemoglobin inside and outside the red blood cell.

For hemoglobin of the western grebe, the oxygen equilibrium is the same inside and outside the erythrocyte with regard to the heme-heme interactions and their pH dependence. The slight increase in p_{50} in hemoglobin solutions as compared with erythrocyte suspensions can be ascribed to the difference in hemoglobin concentration—a dilution effect (*5*).

The Bohr effect—p_{50} as a function of pH—of these avian hemoglobins basically resembles that of horse (*6*) and rat (*7*) hemoglobin in that the bell-shaped curve can be explained on the assumption of two heme-linked groups. However, the reverse Bohr effect (at $p\text{H} < 6$) is much more marked in these avian hemoglobins; the two heme-linked groups are of equal and opposite strength—in contrast to the two mammalian hemoglobins in which the two heme-linked groups are of very unequal strength, a fact that has been made use of with regard to functional structure of the hemoglobin molecule (*6, 8*).

The magnitude of the heme-heme interactions and the oxygen affinity at physiological pH's of hemoglobins of these diving birds are essentially identical to those of the duck (*9*) and, when corrected for temperature, of other birds (*10*).

The equation

$$\phi = \Delta \log p_{50}/\Delta p\text{H},$$

evaluated at pH 7.0 to 7.5, is a useful physiological measure of the Bohr effect (*6*). For rat (*7*) and horse (*8*) hemoglobin, $\phi = -0.60$; for the ordinary dabbling duck, $\phi = -0.67$ (*8*). For the surf duck (see Fig. 1), $\phi = -0.58$; for the western grebe, $\phi = -0.45$. Hence, the Bohr effect is slightly reduced in the surf duck as compared with the ordinary duck; for the western grebe, the reduction is considerably greater.

Perhaps the most salient point, physiologically, in the evolution of diving birds and mammals is the increase in tolerance for lactic acid and CO_2 (*10*). This tolerance ranges from the respiratory center of the brain to—at least for the western grebe—the Bohr effect of the hemoglobin. During diving, such a decrease in the Bohr effect, combined with the well-known decrease in blood flow through the muscles, would prevent a too rapid unloading of O_2, perhaps effecting a saving of that substance for the obligatorily aerobic central nervous system. In addition, during diving and the post-diving acidosis, a large Bohr effect could interfere with the O_2 saturation of blood in the lungs. The finding that the Bohr effect is more reduced in diving birds than in diving mammals (*1*) may be correlated with the findings of Scholander (*11*) that, during diving, the lactic acid of the arterial blood increased relatively more in the duck and the penguin than in the seal. However, Scholander also found that the position of "natural" oxygen dissociation curves of the seals *Halichoerus* and *Cystophora* were shifted much less by changes in CO_2 concentration than were in vitro oxygen dissociation curves of other mammals—including the harbor seal (*1*). The possibility that there is considerable interspecific variation in the phylogeny of physiological adaptations to diving cannot be neglected, especially since the evolution of diving forms has occurred several separate times in both birds and mammals.

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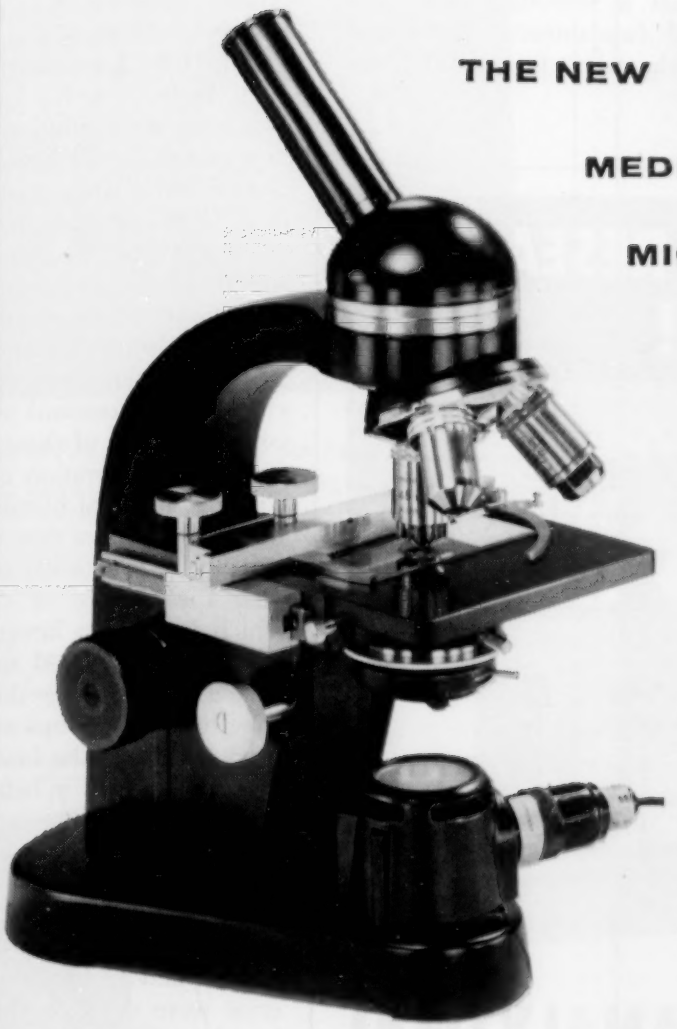
25 November 1957



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Letters

Plan for Producing Significant Research

The appearance of man-made moons, shot up from the U.S.S.R., dramatically highlights the problem of the development of new knowledge in the United States. The situation can be summed up with the statement that the professional, as a rule, beats the amateur. In the modern sense, we have neither positions nor institutions whose primary task is to develop new knowledge. Thus, we have no professional science. We have a fairly good training program for developing scientists, but, after they have been trained, we have no positions for them as creative scientists. They are either employed by industry to develop commercial products or in medical institutions to find a cure for some disease, or they may obtain a teaching position at some university. In all these places creative research occupies a secondary role. The net return of fundamental knowledge compared to the talent invested is insignificant.

Until recently, this method worked, but the development of the professional scientist in the Soviet Union, placed in institutions whose primary object is to develop new knowledge, renders our present method as obsolete as was the bow and arrow when gunpowder was invented and applied to warfare.

Historically, there has been one example of a professional science organization in the United States, established by private funds. In 1902 the Rockefeller Institute for Medical Research was organized for the development of new knowledge. In the next few years, about twelve key men were employed to search for new knowledge in the medical area. Each one of these men had an appropriate number of associates, assistants, and technical services; the administration's role was to create psychological and physical conditions which would stimulate the development of new knowledge. The salaries paid these men were ample to provide a high standard of living. The accomplishments of these few men, during 25 years of operation under this system, changed medical history throughout the world. To cite a few examples: D. D. van Slyke, practically singlehanded, created the science of clinical chemistry which is now an integral part of medicine and has saved innumerable lives. Karl Landsteiner established the knowledge of blood-groups and immunochemistry. This laid the foundation for blood transfusions and a better understanding of vaccination. The indications are that this fundamental work will continue to serve as a reservoir for other practical applications. Alexis Carrel contributed significantly to the field of tissue culture, from which an untold number of discoveries were derived; the Salk vaccine is based on this knowledge. P. A. Levene, a giant intellect, elucidated the structure of nucleic acid, which is the basic unit of heredity and viruses and which is involved in the synthesis of proteins. J. Loeb laid a better foundation for the understanding of proteins, which are the key materials of life.

Later, this program became diluted by a departure from the original principles, resulting in a lowered production of basic knowledge, and thus this scientific institution, although still outstanding, no longer serves as an example of an ideal professional scientific organization. This example serves to illustrate, however, that science on a professional basis in a free society will be highly creative.

The proposal which I have in mind is to establish productive scientific study organized around a relatively small number of unusually gifted investigators—about a hundred of them in each of ten new institutions covering various branches of knowledge. Each one of these scientists should have an appropriate number of assistants and, in addition, should have

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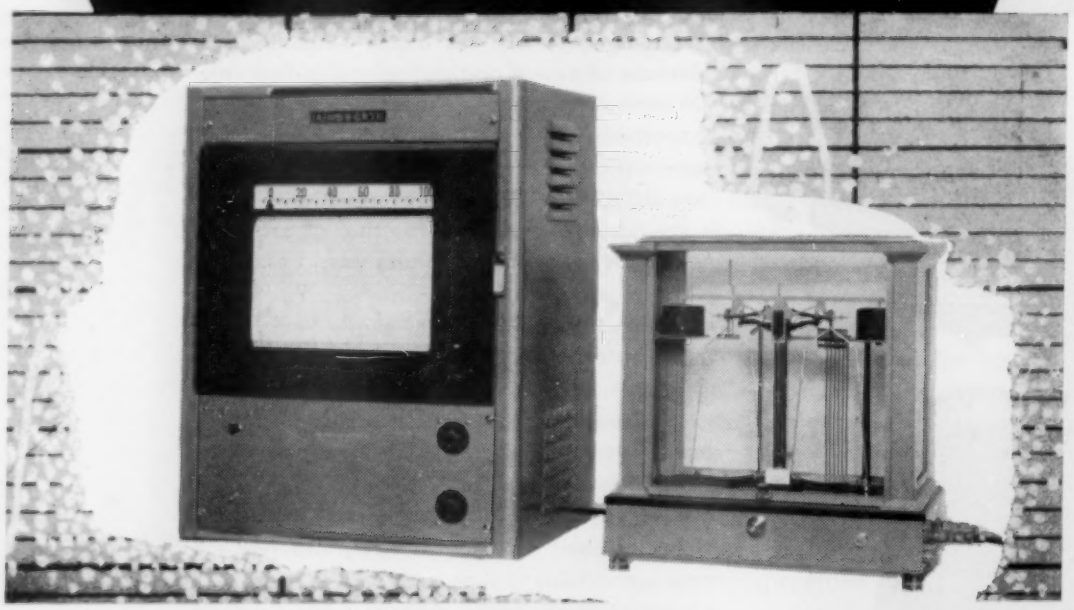

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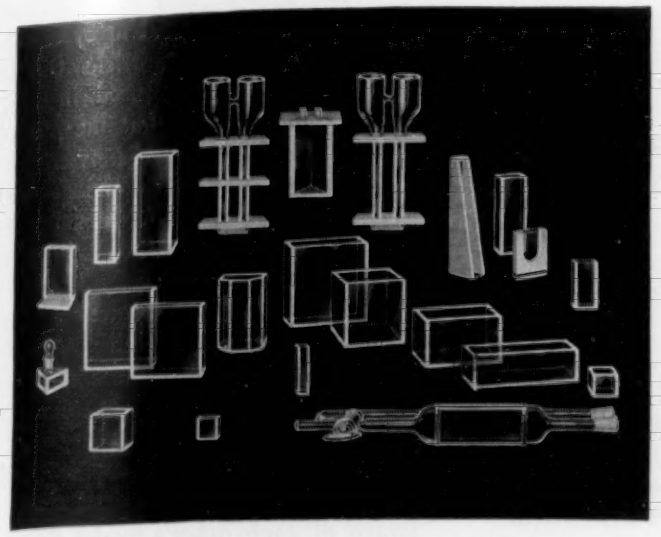

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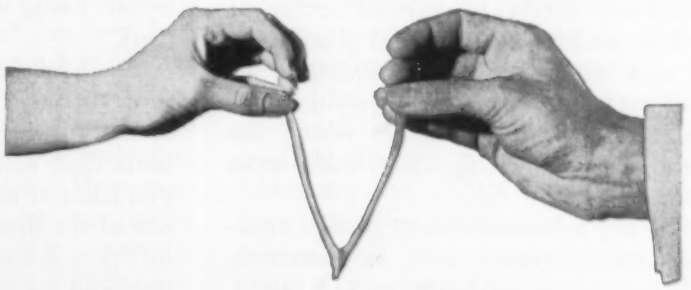

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immediate access to various technical services, such as libraries and glass-blowers' and toolmakers' workshops, and an administration whose purpose is the maintenance of conditions under which the search for knowledge functions most effectively.

The key scientists should possess minimum qualifications, such as extremely high intellectual capacity, proven talent, and first-rate training. They should each receive a salary of $40,000 a year or more, commensurate with the importance of their work to the nation, so that they could be drawn from any field of activity, including industry, and so that continuity of effort could be assured.

Such a development would be a tangible sign, for every gifted young man and woman in this country, that the development of new knowledge pays off. This would provide an incentive for our youth to undertake the study of science as a career. There would be an overflow of gifted, well-trained investigators, assuring qualified personnel for industry, the teaching profession, and project-solving teams (in such fields as missiles and cancer, for example).

I believe that such development in our scientific setup would have a snow-balling effect, resulting in reforms in our educational system, since, once it is realized that there are places to go to in science with self-respect and good pay, it will be seen that there is a good reason for undertaking such training and maintaining such activity.

The introduction of a program of professional scientists functioning in institutions whose primary objective is to develop new knowledge is suggested for three reasons: (i) to provide new knowledge at a faster rate; (ii) to reinforce our existing facilities for the development of knowledge, both in industry and at the universities; (iii) to inspire our youth to engage in science as a career. Our present universities and industrial development methods are essentially sound and should be kept intact, and, in fact, they will be reinforced by the stimulus of new knowledge from such professional scientists, just as they will, in turn, stimulate these scientists. The universities and industry have done a good job and will do an even better job, once we have proper scientific activities that feed new solutions into existing areas of research and create new projects.

The value of such a program of professional science for the United States would be that, when the Russians shoot up a sputnik, instead of merely imitating this accomplishment, we would be in a position to make their accomplishments obsolete. For example, a better understanding of gravity, or of social psychology, could render the threat of the sputniks obsolete. In peace, a foundation for better living and health would be created.

The introduction of such a program of professional science under the leadership of the gifted of the nation, under conditions that will promote more rapid exploration of new knowledge, would be a test of the flexibility of our system and is, in my opinion, essential for the protection and further evolution of the way of life we all hold so dear.

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Jewish Hospital of Brooklyn, Brooklyn, New York

The Maser

With reference to the statement in the article "The maser" by W. H. Culver [*Science* **126**, 810 (1957)] that apparently only in the microwave region of the spectrum can the necessary requirements for maser operation be met, it may be noted that a proposal for a solid-state radio-frequency maser was made by J. Itoh in the *Journal of the Physical Society of Japan* (September 1957).

NORMAN RABBINER
Belmar, New Jersey

Electronic Extension of Optical Observation Techniques

Two articles printed in the special Instrument Issue [*Science* **126** (25 Oct. 1957)] present interesting complementary approaches to the electronic extension of optical observation techniques. Quite interesting, also, is the apparent lack of communication between the adherents of the two methods. We refer to the articles "Ultraviolet television color-translating microscope," by V. K. Zworykin and F. L. Hatke, (p. 805) and "Automatic particle and bacterial colony counter," by H. P. Mansberg (p. 823).

In both techniques, the optical image is decomposed through scanning in order to provide a conventional electronic signal—a voltage which varies as a function of time. Two choices for accomplishing this are available. In system A the illumination on the subject is continuous and undirected during the scanning time. The signal is "read off" the photosensitive element in the camera's image plane as this is scanned by an electron beam. In system B the illuminating system and the photosensitive receptors are interchanged. The light comes from a "flying spot" which scans across the face of a cathode ray tube; this is imaged onto the object, and transmitted or reflected light is picked up by suitably placed photomultiplier tubes. The photomultipliers are continuously active during the scan time.

The interesting and disturbing situation to which we call attention is the following. Although method B can be used in microscopy and has indeed been so adapted by Montgomery, Roberts, and Bonner [*Nature* **177**, 1172 (1956)] in Great Britain and in this country, this fact is not alluded to by Zworykin and Hatke in their article. Similarly, method A could be used in particle counting and sizing—but the possibility is not referred to by Mansberg in his article. Both methods of image translation are used in commercial television—no doubt this complicates the issue through introduction of legal points and competitive business practices. But it seems safe to say that both systems A and B have merit and promise to be quite useful in wide areas of instrumentation and scientific research.

Is it possible that, in the situation cited, the groups involved were not aware of each other's work? Regardless of the answer, the general problem may not be dismissed. This is because it is a general problem. The fact that the practitioners of a method A avoid reference to the work of those who use a method B is but one example of a widespread tendency. Free scientific inquiry is being threatened with suffocation in other areas as well. No doubt other readers are familiar with current examples, even in areas which are vital to our national defense.

As users (for research purposes only) of one of the electronic-optical observation methods mentioned, may we reiterate the following: The erection of artificial barriers between research groups cannot but hinder the progress of all.

J. P. HELLER
L. S. GOURNAY
Magnolia Petroleum Company, Field Research Laboratory, Dallas, Texas

Heller and Gournay are entirely right in stating that the television-camera tube techniques utilized in the ultraviolet television color-translating microscope and the flying-spot tube techniques employed in the particle counter described by Mansberg are both applicable to television microscopy *and* particle counting. However, flying-spot techniques are not suitable for ultraviolet *color translation* microscopy, and reference to them in our article would have been a digression which did not seem justified. Mansberg had, without doubt, equally cogent reasons for omitting mention of articles dealing, for example, with the use of camera tube techniques for making blood counts.

In any case, the authors of the preceding letter are mistaken in attributing the omissions noted to a lack of communications or an effort to erect arti-

ficial barriers between research groups. On the contrary, we have been eager to present research workers in the field with opportunities to compare the several approaches, which would enable them to select more intelligently those best suited for their specific objectives. Thus, on 22 November 1957, the Professional Group on Medical Electronics of the Institute of Radio Engineers held a widely publicized symposium on ultraviolet scanning microscopy, in Philadelphia, at which Montgomery, Bonner, and Hatke gave papers and in which Mansberg participated, to mention only persons cited in the letter. A paper giving a comparison of flying-spot and pickup tube techniques applied to ultraviolet microscopy was included on the program. It is expected that these papers will be published shortly in the *Transactions on Medical Electronics of the Institute of Radio Engineers.*

In brief, we sympathize with Heller's and Gournay's concern that the channels of communication in scientific work remain unimpeded by commercial and other considerations. However, we do not believe that our articles can be cited as evidence of the existence of such impediments.

V. K. Zworykin
Radio Corporation of America Laboratories, Princeton, New Jersey

I agree with Heller and Gournay that the "erection of artificial barriers between research groups cannot but hinder the progress of all." Indeed, this fact is finally being realized even by many nonscientific individuals and is presently the subject of much discussion. However, Heller and Gournay could not have picked a more inappropriate example of the lack of communication between research workers. I have frequently met with all of the people mentioned in the letter and am quite well informed on the nature of their work and results, as they are with my efforts. Furthermore, the value and limitations of both methods of scanning (flying-spot and television-camera tube) are recognized by most of the research workers in this field. In fact, it was recently (22 November) the subject of an excellent symposium and panel discussion on ultraviolet scanning microscopy sponsored by the Philadelphia chapter of the Professional Group on Medical Electronics of the Institute of Radio Engineers.

Both articles published in the instrument issue of *Science* describe instruments designed for a specific purpose. Although the applications of the techniques described are broad in each case, it was not the intention to publish a general discussion of the field of scanning instrumentation.

Perhaps as further evidence that the respective workers are intimately aware of each others' efforts and contributions it should be mentioned that the automatic bacterial colony counter was developed by Carl Berkley, Y. Yamagami, and H. Mansberg. An article by these authors, describing in detail the circuit techniques, will be published soon (*Electronics,* in press). One of these authors, Carl Berkley, is now associated with Zworykin and Hatke and is participating in the color-translating microscope program.

Perhaps one reason that Heller and Gournay are not aware of the degree of interchange of ideas in this field is the fact that so many of the investigators are concerned with medical-electronic applications. I believe that these scanning techniques will find increasing use in industrial research applications, and I look forward to seeing more publication of such effort [see "Flying spot techniques and application," *Du Mont Instr. J.* (Nov. 1957)].

Finally, I would assure them that no "legal points or competitive business practices" were involved either in the design of these instruments or in the preparation of the articles.

H. P. Mansberg
Allen B. Du Mont Laboratories, Inc., Clifton, New Jersey

THE SPECIES PROBLEM

AAAS SYMPOSIUM VOLUME NO. 50
Edited by Ernst Mayr, Harvard University
6 x 9 in., 404 pp., references, index, clothbound, October 1957
Price $8.75; special cash order price for AAAS members $7.50

The symposium was arranged by the Association of Southeastern Biologists and cosponsored by AAAS Sections F and G, as well as four other societies. Most papers are published essentially as given in Atlanta in December 1955. Dr. T. M. Sonneborn, however, undertook a comprehensive survey of the species problem in the protozoans and particularly in the ciliates. His masterly synthesis comprising more than two-fifths of the volume is a fundamental contribution to the protozoan literature.

This symposium made a solid contribution toward the solution of the species problem. It broadened the base on which to discuss the problem by utilizing new organisms. It led to a clarification of the areas of general agreement among biologists. It presented a clear statement of the various species concepts and frankly stated and enumerated difficulties in their application to different types of natural populations. Finally, it illuminated certain aspects of the ageless species problem that had been neglected previously, and it attempted a statement of still controversial issues. From these papers it should be evident that the species problem is still one of the important issues in biology.

CONTENTS

Species Concepts and Definitions
Ernst Mayr, *Harvard University*

The Species as a Field for Gene Recombination
Hampton L. Carson, *Washington University*

The Plant Species in Theory and Practice
Verne Grant, *Rancho Santa Ana Botanic Garden and Claremont Graduate School*

The Species Problem in Freshwater Animals
John Langdon Brooks, *Yale University*

The Species Problem with Fossil Animals
John Imbrie, *Columbia University*

Breeding Systems, Reproductive Methods, and Species Problems in Protozoa
T. M. Sonneborn, *Indiana University*

An Embryologist's View of the Species Concept
John A. Moore, *Barnard College and Columbia University*

The Species Problem from the Viewpoint of a Physiologist
C. Ladd Prosser, *University of Illinois*

Difficulties and Importance of Biological Species
Ernst Mayr, *Harvard University*

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Meetings

Paleontological Research

The Paleontological Research Institution, a recent affiliate of the AAAS, was founded in 1932 by the late Gilbert D. Harris of Cornell University, at Ithaca, New York. A provisional charter was granted in 1933 by the University of the State of New York; the absolute charter, in 1936.

Since its founding in 1932, the institution has made and conducted scientific explorations, researches, investigations, and experiments. In addition to its library of books and journals, it has collected and preserved scientific data, reports, graphs, maps, and documents, making all information at its disposal available by publication, exhibits, lectures, and other means. The institution has held in trust and dispersed certain funds provided for research and scholarships and, in general, has acted so as to stimulate interest and to increase and disseminate scientific knowledge, with particular reference to paleontology.

The organization publishes *Bulletins of American Paleontology* (octavo), now in its 38th volume, and *Palaeontographica Americana* (quarto), in its 4th volume, as well as special publications. The *Bulletins* average about a volume a year on any one phase of paleontology, although special attention has been given to the paleontology and stratigraphy of the Cenozoic of southern United States, South America, and the Caribbean area. *Palaeontographica Americana* consists of detailed descriptive and illustrated monographs of particular groups. Emphasis is placed on well- and fully illustrated papers.

Membership in the institution is obtained by election. At present about one-fourth of the members are from countries other than the United States. Scientists from Canada; from Brazil, Colombia, and Venezuela; from Cuba, Jamaica, Trinidad, and the Dominican Republic; from Czechoslovakia, France, Germany, Norway, Sweden; and from Australia, North Africa, South Africa, and Saudi Arabia are included.

The society maintains headquarters at 109 Dearborn Place, Ithaca, New York. The headquarters building houses between 10,500 and 11,000 type and figured specimens. The publication of a catalog of this material is in progress.

Among its large duplicate collections of invertebrate fossils are the Cenozoic material gathered by G. D. Harris and his students, from South America, the Caribbean, and the United States; the R. H. and D. K. Palmer collections from the West Coast of the United States and from Cuba (*Bull. Am. Paleontol.* **1**, No. 128 locality list); foraminiferal material gathered by H. J. Plummer; Atlantic Refining Company core samples from Haiti and the Dominican Republic; and extensive collections of recent Mollusca.

This is also the headquarters for the publications of the Cushman Foundation for Foraminiferal Research and for those of the late Joseph A. Cushman and the Cushman Laboratory for Foraminiferal Research. Research is carried on at the institution headquarters and by the members at large, under the auspices of the organization.

Meetings of members and trustees of the institution are held at its headquarters the first Saturday of April and October. Election of members is held at that time. New officers are elected at the annual meeting in October. The business meeting is followed by an informal talk and social gathering. A scheduled evening lecture, open to the public, is given by an authoritative speaker on some subject related to geology.

KATHERINE V. W. PALMER
Paleontological Research Institution, Ithaca, New York

Chemical Society's National Meeting

Richard Wistar, head of the Mills College department of physical sciences, is general chairman of the 133rd national meeting of the American Chemical Society, which will be held in San Francisco 13–18 April. Five thousand chemists and chemical engineers from all parts of the United States and several foreign countries will take part in sessions sponsored by 21 scientific and technical divisions of the society.

Chemical advances against disease, recent progress in nuclear energy, and new developments in science education are among the subjects of some 1500 reports to be presented at the meeting. Chemical contributions in many other fields, such as food processing, nutrition, agriculture, fuel, plastics, textiles, and sanitation, also will be described at more than 200 half-day sessions during the week.

Glenn T. Seaborg, Nobel Prize-winning chemist of the University of California, is among the many distinguished scientists on the program. Seaborg, who is professor of chemistry and head of the university's radiation laboratory, will be chairman of a symposium on "The New Elements" sponsored by the society's Division of Chemical Education.

Electronic Waveguides

Internationally known specialists in electronic waveguides will participate in the eighth of a series of international symposia presented by the Microwave Research Institute of the Polytechnic Institute of Brooklyn on 8, 9, and 10 April in the auditorium of the Engineer-

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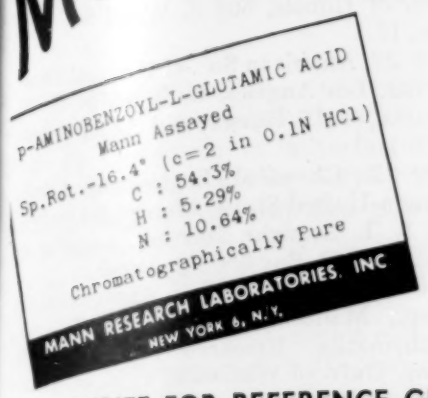

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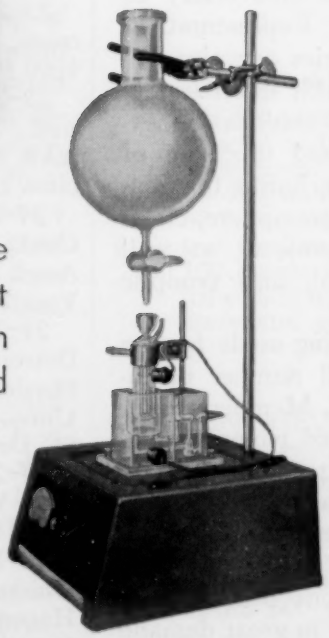

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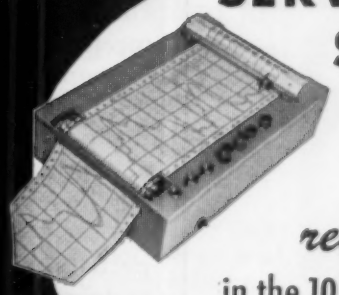

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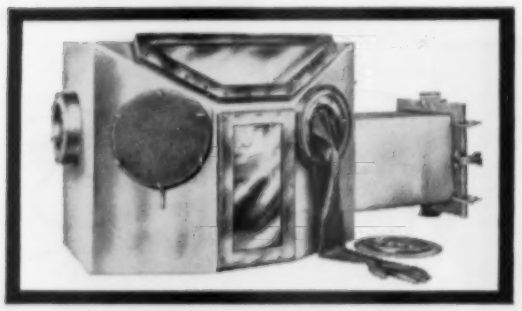

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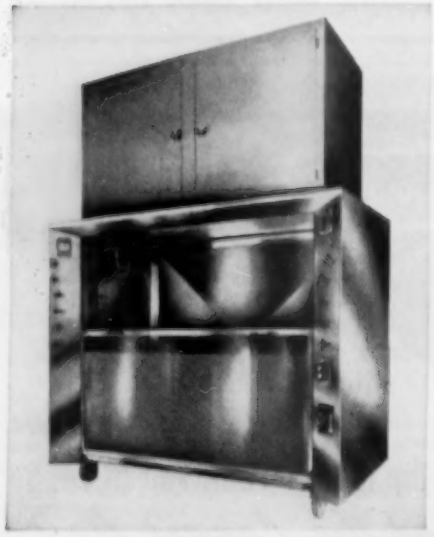

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Scandinavian-American Meteorological Meeting

The American Meteorological Society has been invited by the Norwegian Geophysical Society to participate in a meeting of Scandinavian and American meteorologists at Bergen, Norway, to commemorate the 40th anniversary of the polar front theory. Representatives of certain other countries are also being invited to attend this international meeting. The technical sessions are expected to cover a broad spectrum of meteorological topics, including the general circulation of the atmosphere, cloud physics, and related subjects, as well as dynamical, statistical, and synoptic weather prediction.

Arrangements are being made for the presentation of a small number of invited American papers. Members desiring to present unsolicited papers should submit titles and abstracts directly to Mr. Finn Pederson, Secretary, Norwegian Arrangements Committee, Vervarslinga, Bergen, Norway, *before 15 April.*

Hotel accommodations during June in Bergen are normally in great demand by tourists. Those planning to attend should communicate directly with Mr. Pederson as soon as possible, indicating types of accommodations desired. Robert M. White, Air Force Cambridge Research Center, is chairman of the AMS Committee on the Scandinavian-American Meteorological Meeting.

Forthcoming Events

April

19–25. Industrial Health Conf., Atlantic City, N.J. (IHC, Room 1313, 28 E. Jackson Blvd., Chicago 4, Ill.)

20–22. American Assoc. of Colleges of Pharmacy, annual, Los Angeles, Calif. (G. L. Webster, College of Pharmacy, Univ. of Illinois, 808 S. Wood St., Chicago, 12.)

20–22. American Soc. of Hospital Pharmacists, Los Angeles, Calif. (Mrs. G. N. Francke, 1812 Norway Rd., Ann Arbor, Mich.)

20–23. Chemical Engineering Conf., Canada-United States, Montreal, Quebec, (H. R. L. Streight, DuPont Company of Canada, P.O. Box 660, Montreal.)

20–23. Numerical Approximation Symp., Madison, Wis. (R. E. Langer, Mathematics Research Center, U.S. Army, Univ. of Wisconsin, 1118 W. Johnson St., Madison 6.)

20–25. American Pharmaceutical Assoc., annual, Los Angeles, Calif. (R. P. Fischelis, APA, 2215 Constitution Ave., NW, Washington 7.)

21–22. National Assoc. of Boards of Pharmacy, Los Angeles, Calif. (R. P. Fischelis, 2215 Constitution Ave., NW, Washington 7.)

21–23. American Oil Chemists' Soc., Memphis, Tenn. (Mrs. L. R. Hawkins, AOCS, 35 E. Wacker Dr., Chicago 1, Ill.)

21–28. American Industrial Hygiene Assoc., annual, Atlantic City, N.J. (G. D. Clayton, George D. Clayton and Associates, 14125 Prevost, Detroit 27, Mich.)

22–24. Electronic Components Symp., Los Angeles, Calif. (E. E. Brewer, Convair, Inc., Pomona, Calif.)

23–24. Chemurgic Conf., 2nd annual, Chicago, Ill. (Council for Agricultural and Chemurgic Research, 350 Fifth Ave., New York 1.)

23–26. Internal Medicine, 5th internatl. cong., Philadelphia, Pa. (E. R. Loveland, 4200 Pine St., Philadelphia 4.)

23–27. American Assoc. of Bioanalysts, natl., New York, N.Y. (L. D. Hertert, AAB, Suite 1049, 490 Post St., San Francisco 2, Calif.)

24–25. Eastern States Health Education Conf., New York (I. Galdston, New York Acad. of Medicine, 2 E. 103 St., New York 29.)

24–25. Nutrition Conf., 4th annual, Detroit, Mich. (J. M. Orten, Dept. of Physiological Chemistry, Wayne State Univ., College of Medicine, 1401 Rivard St., Detroit 7.)

24–26. American Mathematical Soc., New York. (AMS, 190 Hope St., Providence 6, R.I.)

24–26. International Scientific Radio Union, spring, Washington, D.C. (J. P. Hagen, National Acad. of Sciences, 2101 Constitution Ave., NW, Washington 25.)

24–26. West Virginia Acad. of Science, annual, Morgantown. (M. Ward, Glenville State College, Glenville, W. Va.)

24–26. Wildflower Pilgrimage, 8th annual, Gatlinburg, Tenn. (A. J. Sharp, Dept. of Botany, Univ. of Tennessee, Knoxville.)

(See issue of 21 March for comprehensive list)

Equipment

The information reported here is obtained from manufacturers and from other sources considered to be reliable. Science does not assume responsibility for the accuracy of the information. A coupon for use in making inquiries concerning the items listed appears on page 718.

■ ANGULAR-ACCELERATION GENERATOR may be continuously adjusted within its range by exchanging or adjusting the position of weights and by varying the winding of the torsion bar that powers the generator. Widely different ranges may be attained by replacing the torsion bar. Acceleration range is thus 0.5 to 200 rad/sec². Motion generated is picked up by a potentiometer of 9000-ohm resistance. (Humphrey Inc., Dept. S958)

■ DIGITAL VOLTMETER compares the input voltage to be measured with an internally generated linear sawtooth voltage wave. When voltage coincidence occurs between the input and the generated reference, a pulse is generated. The time interval between the initiation of the sawtooth reference and the occurrence of this pulse is proportional to the input voltage. The time interval is measured and displayed by an oscillator-counter combination. Accuracy of a four-digit model is ±0.01 percent with encoding rate of 98/sec. Range of 0.1 to 1000 v can be extended to 1 mv by use of external amplifiers. (Servonics, Inc., Dept. S961)

■ ROLLER MICROMETER sorts objects by allowing them to fall between the spaced rollers into a series of bins. Spacing of the two rollers varies from one end to the other so that the objects being sorted fall through the space at a location determined by their size. For example, with spacing differing by 0.001 in. from one end to the other, sorting by groups of 0.00005 in. can be achieved with good consistency. Fragile objects can be handled. (Affiliated Manufacturers Inc., Dept. S963)

■ PRESSURE TRANSDUCER is water-cooled to operate at temperatures of 5000°F or higher. The device combines a diaphragm and a tubular strain gage. Frequency response is constant to 10,000 cy/sec. Accuracy is ±1 percent of full scale, which may be 1000 or 2000 lb/in². (Norwood Controls Division of American Standard, Dept. S965)

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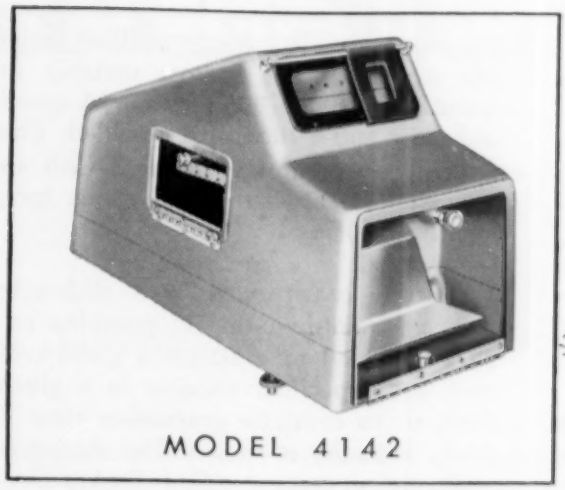
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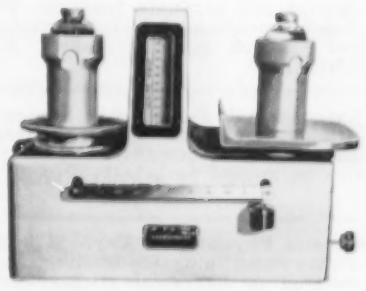

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